VOLUME LVII NUMBER 1 WHOLE 498

SCHOOL SCIENCE AND MATHEMATICS

JANUARY 1957

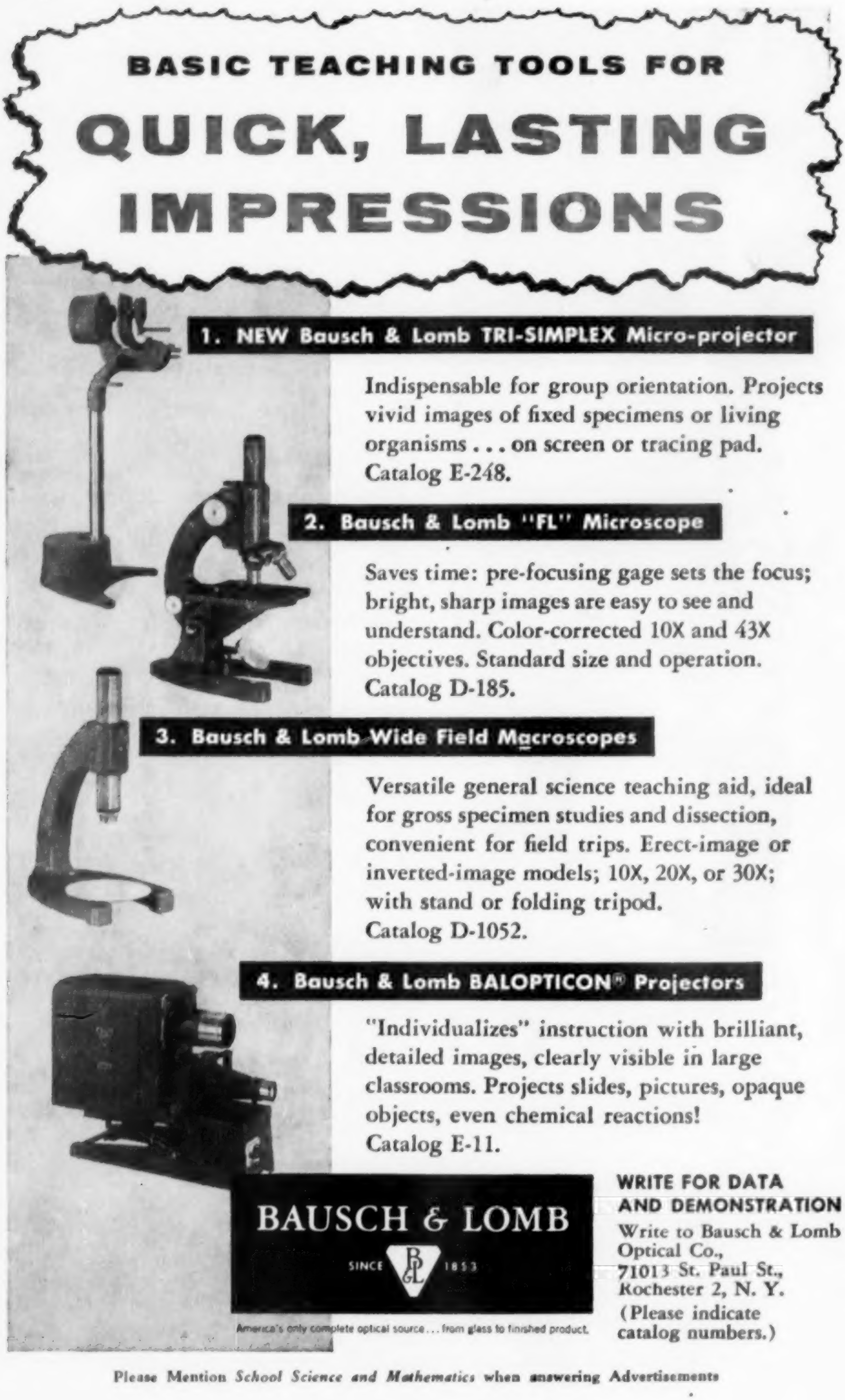
School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

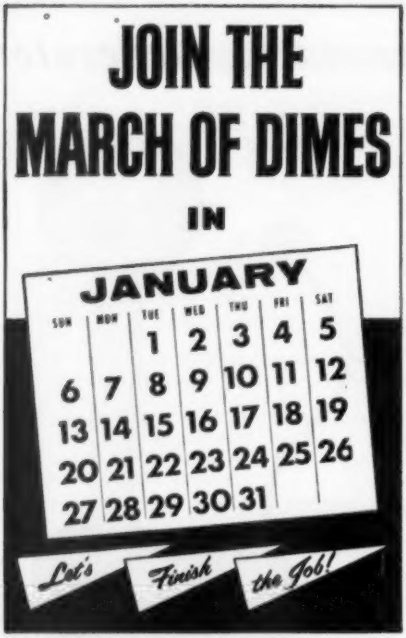
Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE. Four dollars and fifty cents a year; foreign countries $5.00; current single copies 75 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.


BASIC TEACHING TOOLS FOR
QUICK, LASTING IMPRESSIONS
1. NEW Bausch & Lomb TRI-SIMPLEX Micro-projector
Indispensable for group orientation. Projects vivid images of fixed specimens or living organisms . . . on screen or tracing pad. Catalog E-248.
2. Bausch & Lomb "FL" Microscope
Saves time: pre-focusing gage sets the focus; bright, sharp images are easy to see and understand. Color-corrected 10X and 43X objectives. Standard size and operation. Catalog D-185.
3. Bausch & Lomb Wide Field Macroscopes
Versatile general science teaching aid, ideal for gross specimen studies and dissection, convenient for field trips. Erect-image or inverted-image models; 10X, 20X, or 30X; with stand or folding tripod. Catalog D-1052.
4. Bausch & Lomb BALOPTICON® Projectors
"Individualizes" instruction with brilliant, detailed images, clearly visible in large classrooms. Projects slides, pictures, opaque objects, even chemical reactions! Catalog E-11.
BAUSCH & LOMB
SINCE 1853
America's only complete optical source . . . from glass to finished product
WRITE FOR DATA AND DEMONSTRATION
Write to Bausch & Lomb Optical Co., 71013 St. Paul St., Rochester 2, N. Y.
(Please indicate catalog numbers.)

Nothing trains better than the presence of an excellent person. It is not necessary for him to teach or to preach; his silent presence is a sun which warms and gives light.—WOLFF

CONTENTS FOR JANUARY, 1957


JOIN THE
MARCH OF DIMES
IN
JANUARY
SUN MON TUE WED THU FRI SAT
1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31
Let's Finish the Job!

SCHOOL SCIENCE AND MATHEMATICS

Vol. LVII | January, 1957 | Whole No. 498

A HIGH SCHOOL CHEMISTRY CURRICULUM

John W. Renner

Training Officer, Federal Civil Defense Administration, Battle Creek, Mich

Today's high school chemistry course should go on a diet! During the past twenty-five years the high school chemistry curriculum has become more and more obese in content. One reason for this is that today much is known about the structure of matter and the nature of energy that was unknown or speculation twenty-five years ago. The results of these recent advances in the field of science (the foregoing is but one example) have been introduced in the high school chemistry course and properly so. However, the time devoted to studying chemistry in the secondary school has remained static, i.e., one academic year. The problem that faces the chemistry instructor in the present high schools is what *must* be taught and not what *should* ideally be taught.

Chemistry textbooks have given the chemistry instructor some assistance with the selection of content, but as the entire field of chemistry became larger so did the texts, until today the chemistry book which a high school student studies resembles an encyclopedia more than it does a guide to effective learning. Perhaps this is the type of textbook desired by the chemistry instructors in today's secondary schools. If this is true, it reflects the diversity of opinion which exists among present-day chemistry teachers regarding the selection of that content necessary to build a useful, meaningful, and intellectually challenging course.

How should a chemistry instructor proceed in selecting content to construct a course which will be manageable and valuable? The writer believes that the first step which must be taken is to isolate those major areas which will contribute to the scientific growth, through

the study of chemistry, of the students. The writer believes that the major areas are these.

1. "The Tools of Chemistry"—the characteristics of matter and energy
2. Atomic structure
3. The Periodic Chart and its use
4. The Gaseous State of Matter
5. Carbon and Organic Chemistry
6. The Metals

In the introductory phases of high school chemistry it is customary to study the concept that there are three states of matter, i.e., solid, liquid, and gaseous. This is a principle that every student who studies science at the junior high school level should have mastered, but because of its importance it is well to emphasize it again. Chemistry could not be effectively studied if only these generalizations were studied. However, it is a common pattern in today's high school chemistry course to leave the important generalization regarding the gaseous state of matter in the introduction of the course, and proceed to study the gases individually. Some texts have "units" on oxygen, hydrogen, nitrogen and ammonia, and the halogens. A unit, to the writer, means a major understanding. Consequently, is it not more logical to study a unit entitled the "Gaseous State of Matter" and therein study the individual gases than to study them individually as entities throughout the course? If this is done, the study of the parts has been accomplished, and the student has been presented with a whole picture rather than having to piece together this picture because of the sequential divorcement of these topics. Some persons will say that according to the writer's generalization regarding the gases there should also be a unit entitled "solids" and one entitled "liquids." It is believed that such "generalizing" would be "forced." If the material to be studied naturally and logically fits into a common category, it should be studied there. If the principles to be studied must be forced into the same category, they do not belong together and should not be made a part of the same unit. The writer believes that if the content which is studied with respect to the individual gases is examined it will be seen that it fits together quite naturally.

Some of the modern high school chemistry texts have placed together in a common unit that material regarding the metals. For this they are to be commended, and it seems to bear out the writer's contention that the same should and can be done with the gases.

Perhaps even more serious than studying the gases as separate entities is the relegation of the periodic table of elements to a place in the chemistry course where it will be hastily studied, if at all.

Since it usually follows the study of a great many individual elements it is believed that perhaps the reason for this is that the student must understand the elements before he is capable of understanding the periodic chart. Yet one of the first concepts which is usually studied in chemistry is the structure of matter. What better time to introduce the periodic chart and its arrangement, and Moseley's law, than when the knowledge of the structure of the atom is fresh and novel. The writer believes that the periodic arrangement of the elements should be one of the first major concepts which the high school student meets in the study of chemistry. The understanding and functional value of the chart grows as the course proceeds and as the knowledge of chemistry possessed by the students becomes broader, the chart will become a useful tool rather than a mysterious "gadget" or map.

It seems to the writer that there has been one other serious divorcement which has occurred in high school chemistry. It is the separate study of "carbon and its compounds" and "organic chemistry." In some courses these topics are studied weeks apart, thereby depriving the student of the opportunity of gaining a major understanding where one exists due to the nature of the content. Why have such content "divorcements" occurred in what is otherwise, to the writer at least, by the nature of the material, logically organized content? The answer to this rhetorical question lies (it is believed) in the fact that teachers tend to follow the text. A research project recently completed by the writer gave him the opportunity to talk with approximately fifty secondary school mathematics teachers. Only two of these teachers did not use the text primarily as a course outline, and it is believed that there is a similarity between the habits of teachers. Further, an examination of the currently available texts will show that their organization has perpetrated the separation of what the writer believes to be topics that should be studied together in order to give the student the "major understanding" which is so desirable and essential. It has been mentioned that some texts have followed such an organization when discussing the metals.

What useful purpose can be accomplished by reorganizing the high school chemistry curriculum into more closely integrated units of study than now exist? It is believed that such an organization will allow the student to gain a more functional understanding of the entire picture of the foundation stones of chemistry. By organizing a course in a way which the following course outline suggests, the writer believes (because experience in teaching the course in this manner has shown to him that such is true) that the student first gains a perspective of the nature and structure of matter and then begins to comprehend the parts (the elements) that make up the

whole (the periodic arrangement of the elements). If this is accomplished, the students will begin to predict reactions between elements, properties of elements, etc. from a given element's position on the periodic chart. It is the opinion of the writer that at this point the student's knowledge of chemistry has become functional.

The following course outline has been used by the writer in an attempt to make chemistry a logical and functional course. Unsolicited comments by graduates have led him to believe that this arrangement of the content has done this (at least partially).

Unit I: The Tools of Chemistry

1. Matter and its characteristics
2. Mass and weight
3. Gravitation
4. Inertia
5. Law of conservation of matter and energy
6. Energy and work
7. Molecular theory (heats of fusion and vaporization, melting, evaporation, boiling, and sublimation)
8. The scientific method
9. Measurement
10. Pressure and the atmosphere (barometers)
11. The gas laws

Unit II: Atomic Structure and Its Uses

1. Physical change
2. Chemical change
3. Characteristics of a mixture
4. Characteristics of a compound
5. The structure of an atom
6. The relation between atoms and molecules
7. How atoms unite to form compounds
8. Valence
9. The kinetic-molecular theory
10. Avogadro's law (gram-atomic and gram-molecular weights)
11. The structure of the periodic chart
12. Metals, non-metals, and amphoteric substances
13. Natural radioactive elements
14. Artificial radioactivity and isotopes
15. Transmutation and the "man-made" elements

Unit III: The Chemist's Use of the Periodic Chart

1. Types of reactions
   a. Synthesis
   b. Analysis
   c. Substitution
   d. Double replacement
   e. Polymerization
2. Chemical equations (yield problems)
3. Solutions
   a. Solubility rules for water
   b. Types of solutions
   c. Dilute and concentrated solutions
   d. The ionic theory of solution

4. Acids, bases, and salts
5. The electrochemical series

Unit IV: The Gaseous State of Matter

1. Oxygen
2. Hydrogen
3. Nitrogen
4. Ammonia
5. The Halogens
6. The inert gases (He, Ne, A, Kr, Xe, Rn)

All of the above will be studied as to properties, reactions, uses, and some will be prepared in the laboratory.

Unit V: Carbon and Organic Chemistry

1. The allotropic forms of carbon
   a. The diamond
   b. Graphite
   c. Amorphous carbon
2. Carbon compounds
   a. CO_2; in baking, photosynthesis, in fire extinguishers, as a refrigerant
   b. CO
3. Organic Chemistry
   a. The methane (paraffin) series (CnH_2n+2)
      (1) Properties and chemical conduct
   b. Petroleum
      (1) Fractional distillation (Octane rating)
      (2) Cracking
   c. The ethylene series (C_nH_{2n-2})
      (1) Ethylene
      (2) Acetylene
   d. Halogen substitution products of hydrocarbons
   e. Rubber
      (1) Isoprene
      (2) Neoprene
   f. Alcohols
      (1) Methyl
      (2) Ethyl
      (3) Glycerol
      (4) Ethylene glycol
   g. Ether (alcohol→ether)
   h. Alcohols→aldehydes→ketones
   i. Organic acids
   j. Esters
   k. Soap
   l. Benzene

Unit VI: The Metals

A. General information
   1. Location on the periodic chart
   2. Review of the electrochemical series
   3. Definition of an alloy
B. The alkali metals Na and K
C. The alkaline earth metals Ca, Ba, Sr
D. The Lightweight metals Al and Mg
E. The coating metals Zn, Cd, Ni, Sn, and Cr
F. Two heavy metals, Pb and Hg

G. A widely used metal and its alloy, iron and steel
H. The most widely used electrical metal, copper
I. The precious metals, Au, Ag, and Pt

The writer encountered some major problems during the years this course was taught. One of these problems was the availability of textual materials. This was overcome by using a reference shelf and encouraging wide reading from texts that suited students' ability. The reference shelf was made up of high school text books, college text books, some of the "popular" works, and college and high school laboratory manuals.

Perhaps the "highest hurdle" which had to be "cleared" was what type of laboratory manual to use which would be useful to the students and yet make them do more than just "fill in the blanks." No suitable laboratory text (in the writer's opinion) was found. Consequently, it was necessary to construct one. This work has gone through three complete writings and must experience another. However, during the last semester of its use, the writer felt that he was coming close to his objective of teaching a laboratory which was an essential part of the aforementioned content and yet was mainly using "the discovery method."

There is no illusion which exists in the writer's mind that he has settled the polemic question of what content should be taught in high school chemistry. However, if he has thrown any light on the problem and has stimulated others to think constructively about it, the time spent in curriculum research and trial, as well as the time spent in writing this article, has been richly rewarded.

SEE HORMONE ROLE IN HEART FAILURE

When the body tissues get "waterlogged" in patients with congestive heart failure, at least part of the trouble seems to be overproduction of a hormone by the adrenal glands. Studies showing this were reported by scientists at the National Heart Institute.

The adrenal glands are famous as the source of anti-arthritis cortisone and adrenalin. They also produce a hormone called aldosterone which functions in the normal regulation of fluids and salts in the body. Excess quantities of it have been found previously in patients with the waterlogged condition called edema.

Whether the excess was due to overproduction of the hormone or failure of the body to destroy it was not known.

The scientists here collected blood directly from the veins draining the adrenal glands of three normal dogs and five with circulation disorders which had resulted in edema.

Aldosterone appeared in the adrenal blood from the dogs with circulation disorders at over five times the rate it appeared in adrenal blood of the normal dogs. This leads the scientists to conclude that overproduction of the hormone is responsible for the excess in congestive heart failure.

Scientists who made the findings are Drs. Wilmot C. Ball Jr., James O. Davis, Maurice M. Pechet and M. Jay Goodkind.

LISSAJOUS FIGURES[1]

WALLACE A. HILTON
William Jewell College, Liberty, Missouri

About 100 years ago the French scientist, Lissajous attached a mirror to each of two tuning forks. These were placed at right angles to each other so that a light ray directed toward one mirror would be reflected to the other and then to a screen. When the forks were set into vibration the now-familiar Lissajous figures were observed.

In order to explain these patterns which so often are demonstrated on cathode ray oscilloscopes; four methods using the equipment shown in Fig. 1 are used.

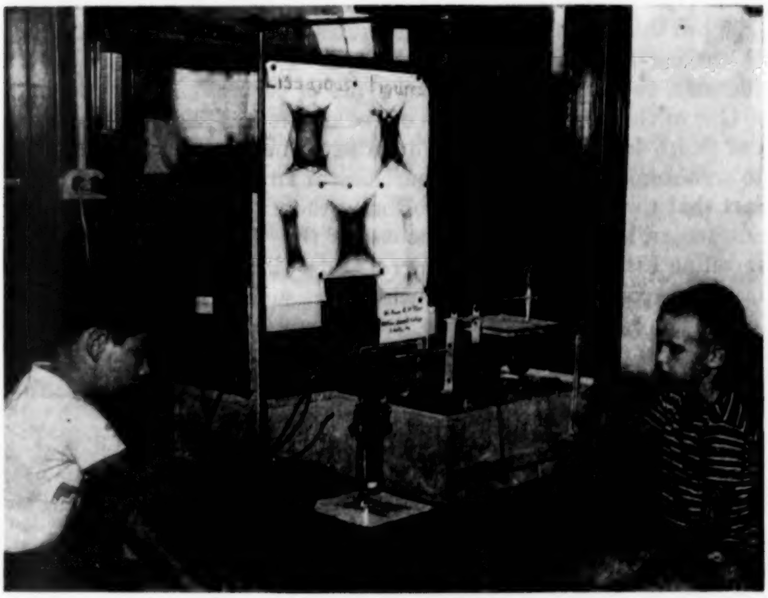


FIG. 1. Apparatus for demonstrating Lissajous figures.

First the patterns are presented on an oscilloscope by applying a 60 cycle per second AC voltage across the horizontal plates of the tube and then connecting the output voltage from a variable frequency audio oscillator to the vertical plates. A large number of different patterns may be obtained in this manner.

A second method is to attach a small penlight flashlight with a focusing lens to the end of a compound pendulum. Arrange so that a

[1] A prize winning exhibit at the 18th Annual Colloquium of College Physicists, State University of Iowa, June 13–16, 1956.

small beam of light will focus on a piece of 8×10 inch photographic paper located just under the pendulum. With the room completely dark, turn on the penlight, and start the pendulum swinging above the photographic paper. After some 25 to 100 oscillations, stop the pendulum and develop the photographic paper in the usual manner. Interesting Lissajous patterns will be observed. The pendulum light is shown at the lower-center of Fig 1 and some patterns obtained by this method are shown in the upper-center of Fig 1.

Another method makes use of two small electric motors which are geared to rotate at a slow speed. One motor moves a ball-point pen back and forth and causes it to under-go simple harmonic motion in a straight line. The other motor moves a small two wheeled cart in simple harmonic motion and at right angles to the motion of the pen. The pen then traces out Lissajous figures on a piece of paper attached to the moving cart. The speed of each motor may be varied by a rheostat, thus producing various types of curves.

One of the simplest methods of demonstrating these patterns is to use "curb feelers" which are intended to be attached at curb level to an automobile and may be purchase at any auto store. Due to the fact that the frequency of vibration of these "feelers" vary at different angles, the small ball at the end of the "feeler" will produce interesting Lissajous patterns when set into vibration. The young man in the lower-right of Fig 1 is about to set such a "feeler" in motion.

ILLINOIS STATE NORMAL UNIVERSITY ANNOUNCES
THE TENTH ANNUAL CONFERENCE ON
ELEMENTARY AND SECONDARY MATHEMATICS

General Theme: The Changing Mathematics Curriculum

Time: April 6, 1957, from 9:00 A.M. to 3:00 P.M. with a social hour following the conclusion of the afternoon session.

Place: Campus of Illinois State Normal University

Speakers: Dr. Bruce E. Meserve and Dr. Henry Van Engen

Dr. Bruce E. Meserve, Professor of Mathematics, State Teachers College, Upper Montclair, New Jersey, will address the secondary teachers. The title of his address is: "The Changing Mathematics Curriculum."

Dr. Henry Van Engen, Head, Department of Mathematics, Iowa State Teachers College, Cedar Falls, Iowa, will address the elementary teachers. He will also use "The Changing Mathematics Curriculum" as the title of his address.

Following these principal addresses, there will be group discussions of interest to teachers on each level: beginners, intermediate, upper grades, and high school Each of these discussions will follow the basic theme of the conference.

We anticipate an outstanding conference, and extend to you a personal invitation to attend its sessions.

DOUGLAS R. BEY, *Chairman*
1957 Mathematics Conference

MATHEMATICS IN THE SOCIAL SCIENCES

HENRY WINTHROP
Hollins College, Virginia

It is being increasingly recognized that the social studies at the college level will require more extensive preparation in mathematics than has hitherto been the case. A recent report from the Social Science Research Council emphasizes first and second year courses in mathematics for students intending to enter the social studies. It is recommended that the content of the first course include the following: (1) logic and set theory including the algebra of sets—10 hours; (2) relations, including order relations—10 hours; (3) axiom systems and the nature of mathematical models—10 hours, (4) functions: linear, quadratic, polynomial, rational, trigonometric, exponential and logarithmic functions, including computations—15 hours, and (5) introduction to the calculus—35 hours. For the second year course the following has been recommended: (1) continuation of the calculus—30 hours; (2) probability—30 hours and (3) matrix theory—20 hours. The report then goes on to state

> . . . "At the outset, emphasis on applications may be needed to motivate students who are primarily interested in social science, and who are studying mathematics with a view toward application. Furthermore, training in abstract mathematics does not automatically transfer itself to training in applied mathematics. On the other hand, there is danger that too much time spent on details of social science content will lead to inadequate mathematical training.
>
> "At both the undergraduate and graduate levels, the integration of mathematical and social science training must not be left to the mathematics department; social science departments must assume at least joint responsibility. Two possible procedures are suggested: (1) Social science departments should offer courses or sections of courses for which mathematical training would be prerequisite, and in which mathematics would be used wherever helpful. (2) Departmental or interdepartmental courses or seminars on applications of mathematics in the social sciences should be given. Such courses should serve to interest students of mathematics and statistics in the social sciences. To this end, it would be advisable to give these courses for several years even for a very small number of students. These courses should stress the translation of social science problems into mathematical form. Some of this translation should also be done in the mathematics courses, but there time will not permit as much as is desirable.
>
> "At present, consultation between social scientists and mathematicians or mathematical statisticians is often difficult, partly because of lack of interest on the part of the mathematicians, and partly because of the social scientists' lack of knowledge as to when and how mathematics is applicable. The program of mathematical training outlined above, if developed and maintained for several years, will greatly improve both communication and understanding.
>
> Social scientists should make an effort to train some mathematicians in social sciences or at least in applications of mathematics to the social sciences, as recommended above with reference to integration of mathematical and social science training. Until more mathematicians and mathematical statisticians minor in social sciences, as they now often do in physics, their communication with social scientists will continue to be handicapped. At present relatively few social science courses are planned to interest mathematicians or to use their special training.

In addition to the courses recommended to facilitate integration, social scientists might consider offering courses or seminars designed for persons not trained in social science but having certain mathematical training.

Finally, social scientists will get better advice from mathematicians who participate than from those who are merely consulted. The most difficult question is often that of the mathematical formulation of social science problems. The social scientist should avoid both limiting the mathematician and having the mathematician limit him."

SCHOOL SCIENCE AND MATHEMATICS has always devoted itself to opening up new frontiers concerned with the role of mathematics and science at all levels of the educational ladder and has published material apprising readers of developments in these new areas. For these reasons the author feels that it would be appropriate to bring to the attention of readers of this journal, an example of current research in the social sciences which implements the recommendations of the paragraphs cited, concerning particularly the nature of mathematical models in the social sciences. I am going to discuss for the reader, the new field of behavioral diffusion theory in the social sciences, and in order to illustrate some of the mathematical work in this new field I am going to select some models from my own work in this area.

Behavioral diffusion theory is concerned with those portions of social psychology and sociology that are devoted to understanding how rapidly and in what ways, *novel, social behavior* spreads throughout a population. It is particularly concerned with the spread of rumor, gossip and information. It is, however, also concerned with the spread of such items of behavior as new slang terms, new social habits such as do-it-yourself hobbies, new fashions, new crazes, values, games, prejudices, etc. In short, behavioral diffusion theory is interested in all social behavior which can be shared. In illustrating below the role of mathematics in this area, however, it will probably be of considerable help to the reader to think of gossip or rumor as the behavior which is spreading. This may make the understanding of the exposition much easier. Much of the work in connection with many of the mathematical models of diffusion theory, has already been experimentally confirmed and will be mentioned in the bibliography at the end of the article. In this paper, itself, I wish to stress only the model-building technique of diffusion theory, without reference to the experimental work in the field, and I shall draw the models discussed from a volume of my own being prepared for publication.

Let us suppose that a rumor started by a single individual is spreading on a person-to-person basis, and let us further assume that statistically speaking, on the average, every person acting as a *transmitter* of the rumor, passes that rumor on to others. Let us further assume that (1) a rumor is adopted after hearing it *only once* and that it is always transmitted beginning with the unit of time following

that of its adoption, and (2) every person who receives the rumor passes it on to ***m persons per unit time.*** We are thus not neglecting the fact that rumormongers may meet converts already made in each time unit *but only that the number of non-converts per unit time met by any transmitter is equal to m.* If every transmitter possesses a circle of acquaintances, D, and if it takes k units of time before he exhausts his circle of acquaintances socially, then, of course, $D=km$. Now let us designate the *total increase* at any time at which $t=i$, by Δ_i. Then the tableau which we shall set forth below will represent the law governing these general increases.

$$\begin{array}{ll} t & \Delta_t \\ 0 & \Delta_0=1 \\ 1 & \Delta_1=m=m(m+1)^0 \\ 2 & \Delta_2=m+m^2=m(m+1)^1 \\ 3 & \Delta_3=m+2m^2+m^3=m(m+1)^2 \\ \cdot & \\ \cdot & \\ \cdot & \\ t & \Delta_t=m(m+1)^{t-1} \end{array} \tag{A}$$

If we now wish to obtain $N(t)$, ***the total number of persons who will reflect the behavior*** (in our example, who have heard the rumor), at time, t, we have that

$$N(t) = \sum_{i=0}^{t-1} \Delta_i = \sum_{i=0}^{t-1} m(m+1)^i+1=(m+1)^t \tag{A'}$$

which is the exponential organic growth law.

Now suppose that we recognize that this growth is curtailed by the fact that every transmitter has a limited circle of acquaintances, D, which represents an average. Knowing this average we can correct equation (A′) for this fact. Essentially what is involved here is that each transmitter ceases to make new converts after ***k units of time***, the period it takes to exhaust his circle of acquaintances, D. However, independent of the fact that he can no longer pass on the novel behavior, is the fact that he may still show it or shed it. It is therefore of interest to follow an analysis of the change in the expression for $N(t)$, by assuming one or the other of these alternatives. We shall therefore analyze the change in the value of $N(t)$ for each of the following two conditions.

(1) After exhausting his circle of acquaintances, D, each transmitter continues to show the new behavior which we shall hereinafter call b_n.

(2) After exhausting his circle of acquaintances, D, each transmitter sheds b_n.

Condition 1

Assume that it takes any transmitter k units of time to exhaust his circle of acquaintances, D. Let us determine $N(t)$ when $t=k+i$ and $i \leq k$. That is to say, we wish to determine $N(t)$ where $N(k) < N(t) \leq N(2k)$. We note that for the previous case, where $1 \leq i \leq k$, $\Delta_i = mY^{i-1}$, where $Y=(m+1)$. At $t=k+1$, the members of Δ_0 will cease to function as transmitting agents, although continuing still to exhibit b_n, and therefore only $N(k)-\Delta_0$ converts will remain as effective converting agents. We shall therefore have that

$$N(k+1) = [N(k)-\Delta_0]m + N(k) \tag{1}$$

$$= N(k) + \Delta_{k+1} \tag{2}$$

$$= N(k)Y - mY^0 \tag{3}$$

$$= N(k)Y - mY^{-1}(Y + 0 \cdot m) \tag{4}$$

where the necessity for the form of equation (4) will soon become apparent. The form of equation (1) consists of two parts: $[N(k)-\Delta_0]m = \Delta_{k+1}$ and $N(k)$ which represents the fact that all converts even at $t=k+1$ still continue to exhibit b_n. This is, of course, restated by equation (2).

At $t=k+2$, the members of Δ_1 cease to function as transmitting agents, so that we have

$$N(k+2) = [N(k+1)-\Delta_1]m + N(k+1) \tag{5}$$

$$= [N(k+1) - mY^0]m + N(k+1) \tag{6}$$

$$= N(k+1)Y - m^2Y^0 \tag{7}$$

Substituting equation (3) in equation (7) we obtain

$$N(k+2) = [N(k)Y - mY^0]Y - m^2Y^0 \tag{8}$$

$$= N(k)Y^2 - mY^0(Y + 1 \cdot m) \tag{9}$$

In general when $t=k+i$, $i \leq k$, the members of Δ_{i-1} *drop out* of the effective population of transmitters, becoming *deadwood* so far as converting potential is concerned, but continuing *to exhibit* b_n. Therefore changes in $N(t)$ for $(k+i)$ when $(k+1) \leq t \leq 2k$, will be a function of the accumulating number of dropouts. We shall accordingly refer to $N(t)$ over $[(k+1), 2k]$ as the *dropout function for* $N(t)$. If the process of iteration employed in order to obtain $N(k+1)$ and $N(k+2)$ is extended in order to obtain $N(k+i)$ we get

$$N(k+i) = N(k)Y^i - mY^{i-2}[Y + (i-1)m] \tag{10}$$

where $i \leq k$.

Substituting $(m+1)=Y$ in equation (10) we obtain the total num-

ber of individuals who exhibit b_n under the constraint that every transmitter will exhaust his $D=km$, over k units of time. Making the substitution gives

$$N(k+i)=(m+1)^{k+i}-m(m+1)^{i-1}-(i-1)m^2(m+1)^{i-2} \tag{11}$$

$$=(m+1)^{i-2}[(m+1)^{k+2}-m^2(i-1)-m(m+1)] \tag{12}$$

$$=(m+1)^{i-2}[(m+1)^{k+2}-m(im+1)] \tag{13}$$

which is the appropriate recursion relationship.

Condition 2

Assume that it takes any transmitter k units of time to exhaust his circle of acquaintances, D. Now, however, we shall assume that *both transmitting potential and the manifestation of* b_n, become extinct after k units of time. We then have a change in both the effective number of transmitters at any time, $t=k+i$, and a continuous decline or falling off from the already achieved value of $N(k)$. We wish to determine $N^*(t)$ where $N^*(t)$ represents the value for the total number of converts to b_n under the operation of both these conditions, namely, that transmitting potential as well as the manifestation of b_n become extinct for any transmitter after k units of time. Let us determine $N^*(t)$ when $t=k+i$ and $i \leq k$. That is to say, we wish to determine $N^*(t)$ where $N^*(k) < N^*(t) \leq N^*(2k)$. At $t=k+i$ we have that

$$N^*(k+1)=[N(k)-\Delta_0]m+N(k)-\Delta_0 \tag{14}$$

$$=[N(k)-\Delta_0]Y \tag{15}$$

$$=N(k)Y-Y \tag{16}$$

$$=Y[N(k)-1]-0\cdot mY^0 \tag{17}$$

where the necessity for the form of equation (17) will soon become apparent.

When $t=k+2$, we have that

$$N^*(k-2)=[N^*(k+1)-\Delta_1]m+N^*(k+1)-\Delta_1 \tag{18}$$

$$=[N^*(k+1)-\Delta_1]Y \tag{19}$$

$$=[N^*(k+1)-mY^0]Y \tag{20}$$

Substituting equation (16) into equation (20) we obtain

$$N^*(k+2)=[N(k)Y-Y-m]Y \tag{21}$$

$$=Y^2[N(k)-1]-1\cdot mY \tag{22}$$

If the process of iteration employed in order to obtain $N^*(k+1)$ and $N^*(k+2)$ is extended in order to obtain $N^*(k+i)$, we get

$$N^*(k+i) = Y^i[N(k)-1]-(i-1)mY^{i-1} \tag{23}$$

Substituting $(m+1)=Y$ into equation (23) gives

$$N^*(k-i) = (m+1)^i[(m+1)^k-1]-(i-1)m(m+1)^{i-1} \tag{24}$$

$$= (m+1)^{i-1}[(m+1)^{k+1}-(m+1)-(i-1)m] \tag{25}$$

$$= (m+1)^{i+1}[(m+1)^{k+1}-(im+1)] \tag{26}$$

. . . .

We now return to our original case. There we assumed that every transmitter met a *constant* number of persons, m, per unit time. Suppose we call the function which reflects the variation in the number of one's acquaintances one contacts over the course of time, $\phi(t)$, leaving the unit of time unspecified. Then in our original case $\phi(t)=m$, that is, $\phi(t)$ is a straight line function for all transmitters. However, let us now reexamine our original set of conditions assuming that $\phi(t)\neq m$, that is, $\phi(t)$ is monotone increasing or decreasing.[1] This will mean that *for all transmitters*, the number of contacts made per unit time is the same. In short, when $t=1$, all transmitters make $\phi(1)$ contacts, when $t=2$, $\phi(2)$ contacts, and when $t=n$, $\phi(n)$ contacts. Upon the basis of these additional assumptions our original set of conditions will give rise to the following set of increases.

$$\begin{array}{ll}
t & \Delta_t \\
0 & \Delta_0 = 1 \\
1 & \Delta_1 = \phi(1) \\
2 & \Delta_2 = \phi(2)+\phi(1)\phi(2) = \phi(2)+\phi(2)\alpha_1{}^1 \\
3 & \Delta_3 = \phi(3)+\phi(1)\phi(3)+\phi(2)\phi(3)+\phi(1)\phi(2)\phi(3) \\
\cdot & \quad = \phi(3)+\phi(3)\alpha_1{}^2+\phi(3)\alpha_2{}^2 \\
\cdot & \\
t & \Delta_t = \phi(t)+\phi(t)\alpha_1{}^{t-1}+\phi(t)\alpha_2{}^{t-1}+\cdots+\phi(t)\alpha_{t-1}{}^{t-1}
\end{array} \tag{B}$$

where $\alpha_i{}^j$ represents the *sum* of j things taken i at a time but considered, however, as entries in ϕ.[2] We would then have for the period of generation, $[1, k]$, the following expression for $N(k)$.

$$N(k) \equiv \sum_{t=1}^{k}\Delta_t+1 = \sum_{t=1}^{k}\phi(t)+\sum_{t=2}^{k}\left[\phi(t)\sum_{i=1}^{t-1}\alpha_i{}^{t-1}\right]+1 \tag{B$'$}$$

It is of interest to see what the tableau of these expansions will look like when $\phi(t)$ is specified. Let us therefore assume $\phi(t)=t$, a fairly simple function. We would then obtain the series

---

[1] This assumption is made for simplicity. Actually $\phi(t)$ may be any function, whatsoever.

[2] Thus the expression $\phi(t)\alpha_2{}^3=\phi(t)[\phi(1)\phi(2)+\phi(1)\phi(3)+\phi(2)\phi(3)]$ since $\phi(t)$ is multiplied by $\alpha_2{}^3$.

$$\cdot \quad 1 \quad 4 \quad 18 \quad 96 \cdots$$

in which the general term is given by

$$\Delta_i = (i+1)! - i! = i(i)! \tag{27}$$

so that the expression for $N(t)$ would be given by

$$N(t) = \sum_{x=1}^{t} x(x)! + 1 \tag{28}$$

. . . .

The mathematical models furnished in this paper are a tiny fraction of one per cent of the models which have been cropping up in diffusion theory, and reflect only the simplest cases in the field. They serve at the same time, however, to show how, with the apparatus of only algebra alone, an analysis of the type of conditions the social scientist deals with, can be successfully met. Similar attacks and model building activities are occurring in the other social sciences, economics, political science, anthropology, psychology and sociology. For an account of model building in the field of diffusion theory and for an account of experimental work along these lines, the reader is referred to the bibliography below. Further exposition of this new field, for readers, may be attempted by the author in the future. If the brief demonstrations given above, however, serve to demonstrate the usefulness of mathematical training in the social studies, thereby emphasizing the recommendations of the report of the Social Science Research Council, our purpose shall have been served.

Bibliography

1. Dodd, Stuart C., Mimeographed reports from the Washington *Public Opinion Laboratory*, Project Revere, 1952.
2. Dodd, Stuart C. and Staff, Testing Message Diffusion in C-Ville, *Research Studies of the State College of Washington*, 20: 83–91. 1952.
3. Dodd, Stuart C., Testing Message Diffusion from Person to Person, *Public Opinion Quarterly*, Summer, 1952.
4. Dodd, Stuart C. and Winthrop, H. A., Dimensional Theory of Social Diffusion, *Sociometry*, 16: 180–202. 1953.
5. Rapoport, A. and Rebhun, L. I., On the Mathematic Theory of Rumor Spread, *Bulletin of Mathematic Biophysics*, 14: 375–383, 1952.
6. Rapoport, A. and Landau, H. G., Contribution to the Mathematical Theory of Contagion and Spread of Information: I. Spread Through a Thoroughly Mixed Population, *Bulletin of Mathematical Biophysics*, 15: 173–183. 1953.
7. Rapoport, A., Spread of Information Through a Population with Socio-Structural Bias: III. Suggested Experimental Procedures, *Bulletin of Mathematical Biophysics*, 16: 75–81. 1954.
8. S.S.R.C. Committee Report: Report of Inter-Society Committee on the Mathematical Training of Social Scientists, *Econometrica*, 24: 82–86. 1956.
9. Winthrop, H., A Kinetic Theory of Socio-Psychological Diffusion, *Journal of Social Psychology*, 22: 31–60. 1945.

10. WINTHROP, H., *A Theory of Behavioral Diffusion. A Contribution to the Mathematical Biology of Social Phenomena*, Unpublished thesis submitted to the Faculty of the New School for Social Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1953.

THE ABILITY OF COLLEGE FRESHMEN TO READ MATHEMATICS TEXTS INDEPENDENTLY WITH UNDERSTANDING

ALBERT E. FILANO
State Teachers College, West Chester, Pa.

"How much can students in freshman college mathematics courses profit from independent reading of their textbooks?" This is a question which has long puzzled conscientious mathematics educators. Some teachers hold that little is gained, in fact, that, more often than not, false impressions and confusion are the result of students reading the textbook without accompanying classroom explanation, while others, welcoming a time saving device or the opportunity to add enrichment materials, assign readings frequently as a normal part of the course work.

Evidence bearing on this problem is presented by an experiment conducted by the writer at the Pennsylvania State University. This experiment sought to determine the extent to which college freshmen can comprehend elements of analytic geometry from reading the textbook.[1] The unit of work covered by this study was that on the hyperbola. Two groups of students, control and experimental (6 sections, 151 students), were employed; the control being taught the hyperbola by usual methods, while the experimental group was given no instruction whatsoever on this material. Rather, students in this group were told to study the hyperbola in the textbook outside of class and that they would be tested on it as they were on other parts of the course. A specific problem assignment on this unit was made from the text, the same assignment given to the control group. There was no slackening of the pace of the course to allow for this outside study; class work continued as usual. At the end of the one week period allotted to the control qroup to teach the unit both groups were administered equivalent objective tests on the hyperbola.

The results of this experiment were analyzed through the use of the Peters Regression Technique,[2] a method of mathematically equating groups. This method involves setting up a regression equation based

[1] Steen, Frederick H. and Ballou, Donald H., *Analytic Geometry* (Second Edition), Ginn and Company, 1946, pp. 77–92.

[2] Peters, C. C. and Van Voohis, W. R., *Statistical Procedures and Their Mathematical Bases*, The Macmillan Co., 1940, pp. 463–69.

on the statistics of the control group, then predicting by it what should be the achievement scores of the experimental group if the experimental factor (no classroom instruction, in this case) produced no differential effect. Thus, the experimental methods were judged successful (or unsuccessful) to the extent that the average achievement of the experimental group surpassed (or fell short) of the average achievement predicted for it.

The following table presents a comparison of the predicted and attained scores for the total experimental group.

Predicted Score (Mean)	Attained Score (Mean)	Difference (Mean)
5.54	6.08	+.54

This information indicates that the experimental group surpassed its predicted achievement; this difference is not, however, statistically significant. The absence of a statistically significant difference leads to the conclusion of a practical equivalence, in terms of student achievement, of the two methods of instruction.

A very careful interpretation of the results is necessary in an experiment of this nature. It should be pointed out that no general applicability of the conclusion to all learning situations is claimed. The unit covered, the hyperbola, is quite similar to the previous, the ellipse, which had been taught in the classroom. Thus, much transfer would be expected, indeed, undoubtedly took place. Therefore, very special conditions were operative in this problem. They are conditions, however, which are met frequently in mathematics courses—situations where the material under consideration has many elements in common with some previous unit which has been taught in detail in the classroom. It is in such instances that the results of this experiment could prove useful.

Two other points require attention. It should not be forgotten that guidance for this outside reading was given in the form of a specific problem assignment. This is very important to any method of instruction as it indicates the type of problem considered important, thus, where the emphasis of study should be placed.

Finally, but not least in importance, the students were held responsible for their readings by the administration of a test. This age old motivator of study is more important here than in any other learning situation. Too often the student does not take assigned readings seriously because he realizes he will not be questioned on them.

In summary, it is felt that this experiment carries important implications for the teaching profession. It illustrates that the often held view that college freshmen can not be trusted to do independent

mathematics reading without accompanying classroom instruction is false. It is false if the material is not entirely new, if guidance is given by means of a problem assignment and if the students are aware that they will be tested on the reading. This being true, the outside reading, handled carefully, could prove valuable in providing more class time for the difficult topics in a crowded syllabus and as a means of adding enrichment materials to a course.

A PLAN FOR TRAINING TEACHERS

Charlotte Main and Lillian Wyckoff
The Baldwin School, Bryn Mawr, Pennsylvania

Vivid and discouraging reports of the present shortages of qualified teachers for secondary school mathematics and science crowd in upon us from all sides. We cannot escape the implications of these reports, for the secondary school training in these fields is vital to the production of technically qualified personnel in all levels of industry and research. It is disheartening to face the fact that large numbers of children will not have a chance to learn to know the fun, the satisfaction and the power which mathematics and science can generate in the human mind, and thus will never consider entering these fields of endeavor.

The Baldwin School believes that the independent school has a responsibility in this regard. As partial fulfillment of that responsibility we have undertaken a pilot study in teacher training in the fields of mathematics and science. This program has been made possible by a grant from the Fund for the Advancement of Education to cover the extra expenses of planning, evaluating, and carrying out the experimental aspects of this plan.

In conceiving and organizing this plan it was our purpose to interest liberal arts graduates in secondary school teaching and to give them such help, encouragement and satisfaction that they would want to stay in the profession. Since we cannot compete with the industrial world in the matter of salaries, we hit upon the idea of offering these young teachers a chance to study in the graduate school of a nearby college, such as Bryn Mawr College, the University of Pennsylvania or Temple University, with an eye to earning the master's degree in a matter of two or three years. In this way we hope to bring into the field of secondary school teaching young people who would otherwise completely by-pass this vital area by going directly into graduate work and college teaching or industrial positions.

It has been especially gratifying that several local industries have evinced interest in the plan and have offered financial help. The du Pont Corporation is paying the graduate school fees for 1956–1957.

Under this plan the school has four teacher trainees, three teaching mathematics and one science. Each of them is completely responsible for three classes and is participating in a weekly planning session directed by an experienced teacher for each course being taught. In at least one of these, planned curriculum study is being carried on. In addition to this each trainee has a weekly conference with the head of her department. Further plans include seminars, about one a month, on such topics as academic standards, professional standards, curriculum planning, proper expression and vocabulary, and general discussion of problems. Professional reading is also being recommended.

Since the direction of the program falls upon the heads of the two departments, they have been relieved of some of their ordinary work. This has been done partly by the revision of their teaching loads. and partly by the use of teachers' aides. The aides are some of our own students and some Bryn Mawr undergraduates who will correct papers, assist in the laboratories, etc., and relieve the experienced teachers to do the planning and direction of the program.

We have been very fortunate in securing the cooperation of a group of nearby schools in the capacity of an advisory committee. These schools are as follows: The Bryn Mawr School, Baltimore; Central High School, Philadelphia; Germantown Friends' School; The Haverford School; The Lawrenceville School; Lower Merion High School, Ardmore; and Radnor Township High School, Wayne. They sent representatives of their mathematics and science departments last May to a meeting in which the general outline of the plan was discussed and opinions exchanged on several points. The committee will stand by to give us counsel at two or three meetings this year.

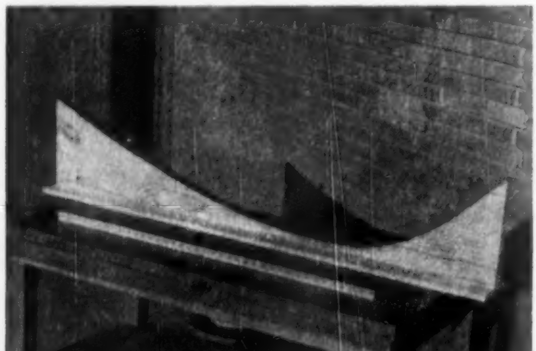
We hope that this is a plan which may prove feasible for adoption by other schools. In our opinion, such a program could be financed by the normal school budget. This study will provide data relative to the most economical and efficient combination of experienced teachers, teacher trainees and teachers' aides. We welcome suggestions, visits or inquiries and will offer the results of our study to any who are interested.

The first reports on the operation of this plan will probably be available in late February or early March. These will include the summary of operations and procedures used in the first semester, financial data and reports from the trainees and their directors.

A CONSERVATION OF ENERGY DEVICE

Julius Sumner Miller
El Camino College, El Camino College, California

A dramatic demonstration piece which is self-explanatory and easy to make is shown in the accompanying photograph.* A 2×8 inch plank (planed down in thickness to about $1\frac{5}{16}$ inches), 5 or 6 feet long, is cut in a sweeping curve so that one part is much longer than the other. On the curve are fixed two strips of cold roll, $\frac{5}{16}''$ by $\frac{1}{2}''$, with a separation of about $\frac{5}{16}''$. This separation provides a track on which a $1\frac{1}{2}$ inch steel sphere may roll. The plank is fixed in a vertical plane to a horizontal base 6 or 8 inches wide to give it stability. Only two precautions are necessary: the steel rails must be fixed to the wood, with counter-sunk screws, say, at close intervals to avoid sway in the track, and their separation must be everywhere the same, otherwise wobbling results.



If, now, a steel sphere is released from the top of the track at one end it can, *at best*, go no higher than the top at the other end. The impulsive feeling, however, to which students fall victim, is clear: does not the rolling ball have a *longer* time and a *longer* path in one case and will it not thereby gain a *higher* velocity which will put it over the top at the other end? Indeed, in demonstrating it, one should roll the ball first down the longer track and I must proclaim that there arises a dramatic moment! Since steel on steel (and a drop of oil helps) is so very friction-free the energy losses are trifling small and not only is the *first* trip possessed of suspense but the motion continues back and forth for an astonishingly long time.

---

* I am indebted to my colleague Dr. F. E. Deloume for preparation of the photograph.

SOME TRENDS AND PROBLEMS IN TEACHING SCIENCE IN THE ELEMENTARY SCHOOL

M. IRA DUBINS
The School of Education, Northwestern University, Evanston, Illinois

Since there are many misconceptions as to what science in the elementary school should consist of, I would like to present what science educators think it should be. Science at the elementary school level should be the study of one's physical and biological environment; the building of a foundation upon which one's future understanding of the world in which one lives is based; the development of problem-solving ability which will enable the individual to more easily solve his future problems; the acquisition of attitudes which are termed scientific such as accuracy, curiosity, intellectual honesty, open-mindedness, the habit of looking for natural causes, suspended judgment, criticism, and so forth. It should not be straight identification, memorization of obscure names, technical, just reading, or diluted high school content.

In order to understand the reasons behind most of the trends and problems in the teaching of science in the elementary schools today we must examine the events of the past decade. In 1946 there were about 10,000 television sets in the U. S. New York City had half, and the remainder was in Chicago, Los Angeles, Schenectady, and Philadelphia. In 1954 over 60% of the homes in the U. S. had at least one TV set and there were almost 400 TV stations broadcasting programs in over 225 cities. Within the past decade we have had an avalanche of advances in applied science. For one person to keep up with these new developments is like a piper cub trying to overtake a jet plane. I would like to mention some of these developments. A list of advances in applied science according to various categories follows:

Entertainment:

better color film for photography
the polaroid camera
cinerama, cinemascope, 3-D
high fidelity radio phonograph
improved television
color television
smaller radios
portable television sets
tape recorder for sound
tape recorder for television programs
stereophonic sound
long playing records

Home

aluminum foil
automatic receptionist
home heating
foods . . . frozen, irradiated
electronic ovens
improved appliances . . . washing machine, dryer, dishwasher, disposal, freezers
new detergents
long distance dialing
plastics (furniture, etc.)

Industry

atomic battery
solar battery
automation
improved computers
synthetic diamonds
electronic lighting
synthetic fibers

plastics
transistors
Texas Towers
new large excavating machines used in road building
power from the atom

Medicine

newer antibiotics
helium for respiratory ailments
hormones . . . ACTH, Cortisone
oral insulin
operations
Salk Vaccine
radioactive cocktail
trace elements
vitamin B-12

Transportation

atomic submarine
now working on atomic plane
automobile tires which do not blow out
plastic bodies for automobiles
telephone in cars
turbine-powered automobiles
jets
fog dispeller

Increase in man's knowledge

atomic structure
atmosphere
radiocarbon method in dating
trace elements
rockets
radar bounced off the moon

In different homes different advances in science may be discussed. For example, a person who has been bedridden for years may sing praises of ACTH, because now he can perform tasks for the first time since he acquired arthritis. He must take an injection of ACTH once a day or else his pains will return, but still to him ACTH is performing a miracle. His children and the neighbors' children hear from him about this great substance. Their curiosity is aroused.

Junior, an exceptional student receives a transistor kit from his uncle. He brings it into school and the other children become interested, but the teacher who had difficulty with Ohm's law in college looks with horror at this transistor and kills the interest, instead of using this as a starting point of a unit on electricity.

Louise has an uncle in the navy and he is a member of the USS *Nautilus*. On leave he visits his brother, Louise's father, and naturally is plied with questions about this submarine. How does it differ from the regular submarine? How fast can it go? Louise, aged ten, overhears the questions and answers. What an opportunity to show off. How many other kids in the neighborhood have relatives who are on the crew of an atomic submarine. The interest of her classmates is raised to fever pitch and is shown by the questions they ask the teacher and themes which they write.

Joe's sister received a wrist watch radio from her boyfriend. Joe, aged thirteen, wants to know why we didn't have them before. How do they differ from regular radios? Why do they cost more than larger radios, he asks.

Myrtle's dad has a radio which is charged by sunlight. Henry's father sells tape recorders. Martin has a brand new hearing aid. Tom who just enrolled in the school last week has a brother who is a jet pilot. On TV last night some uranium prospectors had irradiated meat

and no ice, yet could eat for a month without the food spoiling. Was this really possible? And so it goes.

All these developments have combined to create more interest in science than ever before among elementary school children, yet a smaller percentage enter science, mathematics, engineering, and the teaching of these fields than ten years ago. Why? An attempt shall be made to explain this enigma in the second part of this article.

I. Some Trends in the Teaching of Elementary Science

Problems in the teaching of science result in new trends if attempts are made to solve the problems. Today's problems will result in new trends of tomorrow. The problems we had yesterday are resulting in the trends we see today. The trends have been placed into the following categories:

A. the curriculum
B. methodology
C. recognition of individual differences
D. textbooks
E. teachers

A. *The Curriculum*

1. There has been an increased awareness of the importance of science in our lives and this is causing people to wonder about the science curriculum in the elementary schools. For example, Linus Pauling, a pure scientist and chairman of the department of chemistry at the California Institute of Technology said:

> "Through experience we have learned that the way to teach mathematics is from the kindergarten up in all grades . . . the time has now come for the study of science to be made a part of the curriculum in every grade, in every level through high school and college . . . only in this way can we train citizens for life in the modern world. Only in this way can we develop a citizenry able to solve the great social and political problems confronting us in this world."[1]

2. More and more schools are introducing science into the elementary curriculum each year, either as a separate subject, or combined with social studies.

3. Science in the elementary curriculum is receiving greater emphasis. Some of my students who are teachers in a large system just south of Evanston told me that their city now has administrators pushing science.

4. There is a trend toward building a science curriculum from the kindergarten where there is one (otherwise the first grade) to the 12th grade.

5. More schools are drawing up courses of study and curriculum

[1] Pauling, L., "It Pays to Understand Science," *Science Digest*, May, 1951, pp. 52-57.

guides in elementary school science, and these courses of study and curricular guides are to be used as suggested references, rather than manuals.

6. School systems are studying their science programs and trying to improve them.

B. *Methodology*

1. More physical science is being taught in the elementary science program than formerly.

2. Nature study is being relegated to its proper niche in the overall science program.

3. There is a trend towards using more activities in the elementary science program. It is being accepted that science cannot be learned by just reading.

4. More use is being made of community resources, including human resources. The secretary of the Chicago Natural History Museum told me that one day in May there were groups of students from 72 different schools visiting the museum. In one of the Winnetka public schools a retired gentleman whose hobby is carving birds from wood, visits the elementary schools and permits the students to watch him. Another person who has records of animal voices brings his collection in and plays them for the children.

5. More classrooms have science corners, have science materials on display, are not as barren as previously.

6. An attempt is being made to build science experiences around problem-solving.

7. Science in the elementary schools is becoming more introductory, exploratory, and broad rather than technical, intensive, and narrow.

8. Materials for the elementary science program are being drawn more and more from the child's immediate environment, rather than distant, unrelated, unique and exotic locales.

C. *Recognition of Individual Differences*

1. On a very limited scale more opportunities are being provided for pupils to do projects in the field of science in which they are interested. Science fairs for pupils through grade 8 (if grades 7 and 8 are included in the elementary school) while not widespread, are increasing in number.

2. The Future Scientists of America has an annual program for students in grades 7 and 8 in which they submit projects and written reports and then are awarded prizes after their projects have been judged. This is wholesome competition and stimulates interest in science and mathematics. The Haven school in Evanston had one

of the highest proportion of prize winners in the United States in 1956.

D. *Textbook Series in Elementary Science*

1. There are more series of elementary science textbooks than ever before.
2. The science textbooks are more attractive.
3. There are more textbooks with experiments for the student to perform.
4. The science textbook is losing its former function of being a reader only.
5. The science textbooks cover a wider range of material.
6. There is a tendency to introduce some of the basic concepts of chemistry and physics, especially in regard to the structure of matter in the fifth grade.

E. *Trends among Teachers*

1. More teachers are taking courses in the teaching of science.
2. The courses in the teaching of science have shifted their emphasis from methodology to content.
3. More workshops are being offered in science.
4. Teachers have realized their shortcomings in science and are trying to improve themselves.

II. Some Problems in the Teaching of Science in the Elementary School

The following problems in the teaching of science in the elementary school will be considered:

A. Why do children's interests in science decrease from the primary grades to the high school?
B. The background of the elementary school teacher
C. What should a teacher do when children ask questions that she cannot answer?
D. What to do about equipment and storage
E. Grade placement and its significance

A. *The Decline of Children's Interests in Science*

In the first part of this article I raised the question why with increased interest and opportunities for interest in science a smaller percentage of people is entering the fields of science, mathematics and engineering and the teaching of these fields. One of the greatest problems today is determining why children's interests in science decrease from the primary schools continously through the high schools. They are certainly exposed to science in their environment

and through the medium of television. One study made on questions children ask revealed that in the first grade the children ask 65% of the questions whereas in the sixth grade they ask only 5% of the questions. Along the way they become discouraged by adults and by teachers. The teachers cannot be blamed too much, that is those who have the large classes which means most teachers. The children realize when their questions are passed off, or are answered by over-eager parents in an encyclopedic fashion that there is no use in asking questions as it results in frustration. We have got to maintain, encourage, stimulate, and further children's natural interest in science. I say natural because all children entering school are curious. They are interested in their physical and biological environments. They are explorers. In other words, they have one of the scientific attitudes.

B. *The Background of the Elementary School Teacher*

Related to the previous problem and one of the most serious is the background of today's elementary school teacher. I say this casting no aspersion on the individual teacher, but to criticize those members of the college faculties all over the U. S. responsible for the deficiency of the teacher in science. I would like to quote from an article by Louisa Pike in the February 1950 edition of the *National Elementary Principal* entitled "The Teachers Speak To Their Principals." Mrs. Pike is a science supervisor in Seattle. One of the teachers said the following to her:

> "Science means something highly technical that I know next to nothing about. Besides, I can think of no way in which this complicated and difficult thing I struggled with in college can give opportunity for enthusiastic learning activity for kids. Probably it was the high school and college teachers who first frightened me about science. I survived the lending library of facts and ideas to be taken out one week and returned the next week and became a good little performer. I memorized with the best of them. But I developed a dislike for science and now that I have to teach it I am afraid of it."[3]

I have selected this statement because it is typical of most of the teachers in the elementary schools and on numerous instances identical statements have been made to other educators and myself throughout the U. S.

Science educators and elementary educators are agreed that the average liberal arts science course whose enrollment consists of pre-medical students, science majors, pre-dental students, pre-teachers, and others is not suitable for people who are going to be teachers in the elementary school. However, in most universities there are no special background courses in science for the future elementary

---

[3] Pike, L., "The Teachers Speak to Their Principals," *The National Elementary Principal*, February, 1950, pp. 9–11.

teacher, or even the in-service teacher. In many colleges there is a general education course in science taken by all non-science majors. This course is not suitable for the future elementary teacher. Many institutions require that future teachers of the elementary school take one course in science if they are to teach primary, and two courses if they are going to teach intermediate grades. This is ridiculous. The future teacher of the elementary school needs science subject matter in the physical and biological sciences . . . some physics, chemistry, biology, geology, meteorology, and astronomy. However, if she selects one or two sciences she gets a technical background and knows a lot about a little and a little about a wide field. The sort of laboratory experiences and other activities she has in these courses are not transferable to the students she will teach. Obviously she cannot take all these sciences, so some plan must be devised whereby special courses cutting subject matter boundaries are provided so that the elementary school teacher will have an understanding of the basic principles of science as a whole, and not just one or two areas of specialized science.

The elementary school teacher who is provided with a good science background, good from the viewpoint of a science educator and not a pure scientist, who has had in her college work the opportunity to work with simple equipment to illustrate the science principles she has been studying will have confidence in her ability to teach and work with children in science in the elementary school. She will do an excellent job of teaching science.

The elementary school teacher who has the typical liberal arts science background consisting of one or two courses in science, or a survey course in general education science and who has to digest both the professor's lectures and the often emetic material of the technical textbook without benefit of appropriate "cooking" equipment, will not have any confidence in her ability to teach science to children. As a matter of fact she will have mental blocks and fears, and these will be transmitted to the children who will have their initial interest in arithmetic and science weakened to such an extent that it may be dissipated. This type of teacher will not teach science unless the principal orders her to do so, and then she will (and we have all seen this) teach science by having Mary read a paragraph out loud and then having Herman read another paragraph, and this will be her science program.

C. *What Should a Teacher Do When Children Ask Questions that She Cannot Answer?*

The teacher in the elementary school cannot be expected to know everything in science no matter how excellent her background is.

And this brings us into another of the problems in the teaching of science in the elementary schools. What should the teacher do when she does not know the answer to a question a child asks? Herman Bumpus said that a person who does not learn is a dead teacher. Bumpus, now gone to his reward, was a great teacher and college and museum administrator. He was a pioneer in removing the complex latinized names from museum specimens and having them replaced with common names and simple explanations so that the layman could understand and enjoy museum exhibits. When a child asks you a question that you cannot answer, tell the child that you do not know the answer, but that you will be glad to help the child find out. Do not have a feeling of inadequacy because you cannot answer a child's question. Because of the tremendous strides in science within this century and just within the past decade, one cannot be expected to know all the answers. One of the objectives in our teacher training program is not the preparation of walking encyclopedias. One of your objectives in teaching science in the elementary schools is not the preparation of walking encyclopedias. As Henri Poincare, the great French mathematical scientist, said "Science is made up of facts as a house may be made up of stones, but science is no more a heap of facts as a house is a pile of stones."

A very worthwhile objective is teaching children how to find out. Perhaps the child's question can be answered by a simple experiment he could do. He sees a child holding a balloon on a string and the balloon is floating in the air. He asks you if he blew up a balloon with air from his lungs and attached it to a string would it also float in the air. You do not remember that air from his lungs contains more carbon dioxide and that it is heavier than air, so the balloon will not float, but fall to the ground. Tell the child "let's get a balloon, blow it up, and see."

In learning how to find out children develop self-confidence and self-direction. It is an excellent way in which self-reliance can be developed.

If a child asks a question such as what causes rain, perhaps other children are interested in this same phenomenom. Collect the children's questions and plan a unit. If a child asks a question such as what good are magnets and you have had no courses in which magnetism or electricity were discussed, read up on them, ask the high school science teacher about anything you do not understand concerning these topics. Borrow equipment from the science kit your school may have, or the junior high school, or science teacher and experiment. Learn with the children. They will respect you all the more. They will not say in their private conversations with their classmates, "Don't ask Miss Wilson, she won't give you the answer."

They will say, "Ask Miss Wilson, she may not know, but she will help us find out."

D. *What to do about Equipment and Storage*

Another major concern in the teaching of science in the elementary schools is equipment. What materials does a teacher in the elementary schools need for her science program? Fortunately, almost all of the equipment is simple and inexpensive, and the storage of it is the problem, rather than the obtaining of it. There is certain equipment that one has difficulty in duplicating such as tuning forks, dry cells, buzzers, bells, a hot plate, tinners nips, microscope, etc. A microscope does not have to be purchased, but can be borrowed from the high school biology teacher, or the junior high school science teacher, or some pupil whose father is a doctor and does not have much use for his microscope.

It is a good idea to let the pupils participate by having them bring in equipment which can be used for experiments and demonstrations. Equipment such as metal cans, balloons, glass jars, pieces of electrical wire, corks, aluminum plates, magnets, magnifying glasses, electrical switches, and pyrex dishes will be useful.

The principal should have a petty cash fund available in the event that his teachers need certain items for their science work. She should see that there is a place for the storage of equipment, perhaps a centralized room so that all elementary teachers would have access to the equipment which could be kept in labelled boxes.

E. *Grade Placement*

The problem of grade placement, or what to teach at the different grade levels is in the parlance of the athletic world a "sleeper." Its significance is known to but few and its importance is underestimated by most of the teachers and administrators. Many solve the problems by teaching what is in the textbook and concern themselves no further having considered the problem to be solved. However, we cannot and should not accept this method of solution.

Why should we concern ourselves with grade placement? The tremendous increase in scientific knowledge has resulted in considerable widening of the gap between the scientists and the non-scientists. If nothing is done to remedy the situation, then the gulf will be so wide that it will become unbridgeable. What can we do? We have got to find out at what level in the elementary school we can best introduce the basic concepts and principles of science. We need a revision of the curriculum in science from the kindergarten through the 12th grade, and also in college.

The material appearing in textbooks has been placed there be-

cause of surveys made of other elementary science textbook series and courses of study and curriculum guides. In other words, except for very, very few cases it is a continuation of the status quo. In science where the status quo exists stagnation results, and stagnation in science today may result in slavery or forced conformation to other ideologies tomorrow, or decay of our economic system.

Many educators say that it makes no difference what is taught in science in the elementary grades as long as it is not technical, as long as it enables the students to be exploratory, as long as it enables the major objectives in the teaching of science in the elementary schools to be attained. However, when children are exposed repeatedly to the same topic with no opportunity for growth as they advance in the elementary school and when there is much material which is neglected, I believe that a major problem is involved.

There is certainly confusion and waste of precious time when in the same school the second grade teacher does not know what the first and third grade teachers are doing in classwork. There is confusion and frustration among the students when certain concepts and principles are taken up before they are ready or mature enough to understand them, or to see their significance.

Many studies have been made concerning grade placement, but of these not very many are research of significance. Perhaps the best way of studying grade placement is for the research person to visit the elementary schools and try teaching different concepts and principles at different grade levels to determine the range of the learning and growth that takes place and then tie this in with the background and mental ability of the student. This is no easy research problem. Individual differences and differences in teaching ability will complicate matters. However, what other way of finding out what can be taught to pupils at different grade levels can be used?

Let us remember that although a piper cub represents an advance over an automobile, we can't use piper cubs today to keep our position with respect to the world. We must use jets. The curriculum of twenty years ago is equivalent to an automobile. Today's curriculum in science in the elementary school is equivalent to a piper cub. Therefore we must redesign our elementary science curriculum if we want to maintain our world leadership. We need a jet propelled science curriculum in today's elementary schools.

Bibliography

Blough, G. and Huggett, A., Methods and Activities in Elementary School Science, Dryden Press, New York, 1951.

Brown, S., "Trends in Science Education 1953," *Science Teacher*, 21: 84–5, March, 1954.

BURNETT, R. W., Teaching Science in the Elementary School, Rinehart and Company, New York, 1953.
CRAIG, G. S. Science for Elementary-School Teachers, Ginn and Company, Boston, 1948.
DUBINS, M. I., Current Practices in Elementary School Science with Reference to Courses of Study Published from 1940 to 1952, and the Extent of Activities Undertaken for the Improvement of Instruction, Unpublished doctorate dissertation, Boston University, 1953.
GEGA, P. C. "Elementary School Science—Some Problems," *Science Education*, 40: 237–240, April, 1956.
HURD, P., "Midcentury Trends in Science Teaching," *California Journal of Secondary Education*, 28: 244–250, May, 1953.
LAMMERS, T. "The 31st Yearbook and 20 Years of Elementary Science," *Science Education*, 39: 39–41, February, 1955.
MALLINSON, G. G. AND BUCK, J. V. "Some Implications and Practical Applications of Recent Research in Science Education," SCHOOL SCIENCE AND MATHEMATICS, May, 1956.
NATIONAL SOCIETY FOR THE STUDY OF EDUCATION, "Science Education in American Schools," Part 1, University of Chicago Press, 1947.
NELSON, V. AND BROWN, S., "Perceptible Changes in Science Education," SCHOOL SCIENCE AND MATHEMATICS, December, 1954.
PAULING, L. "It Pays to Understand Science," *Science Digest*, May, 1951.
PIERCE, R. "Curriculum Trends in City School Systems," *Science Education*, 39: 223–224, April, 1955.
PIKE, L. "The Teachers Speak to Their Principals," The National Elementary Principal, February, 1950.
RASKIN, A., written communication (Chairman of Committee on Educational Trends, National Association for Research in Science Teaching) June, 1956.
SKILKEN, J., "Needed New Science Curriculum," *Science Teacher*, 21: 233, October, 1954.

DEMAND FOR ENGINEERING AND SCIENCE GRADUATES

Up, up and up go the starting salaries for college graduates and where the end is nobody seems to be able to predict. Charles E. Wangeman, head of the Bureau of Placements at Carnegie Institute of Technology, announced today that the median starting salary for 1956 Bachelor of Science graduates at Carnegie Tech was $425 per month, or about $40 a month more than last year.

"With the continuing demand for graduates," Mr. Wangeman said, "starting salaries will rise again next year—probably to a median of $450 per month. Where this salary boom will end nobody can safely say although it will surely not stop while industry continues their fight for graduates and the nation's cost of living continues to rise."

Mr. Wangeman added that, "this has been a hectic year for college placement bureaus and Tech is no exception. During the school year 1955–56, approximately 700 companies contacted us about employing graduates of the June 1956 class from the College of Engineering and Science, School of Printing Management and the Graduate School of Industrial Administration."

"Of this number, 307 companies sent 544 representatives to the campus and 4,535 individual interviews were arranged. The demand was so great that 115 companies were cancelled for lack of students available for interviews."

Of the 448 day school graduates, 305 or 68 percent were employed by industry; 110 or 25 per cent in academic pursuits, either in graduate study, teaching or research; and 18 or four per cent entered government service either in a civilian capacity or as members of the armed services. The remaining three per cent included foreign students who returned to their native countries and those who failed to answer the placement office employment questionnaires.

DIMENSIONAL ANALYSIS

C. H. Scott
California State Polytechnic College, San Luis Obispo, Calif.

I. Introduction

Scientists are continually running on to problems of how to test existing formulae for plausibility, how to change from one type of unit to another, and how, simply to develop new formulae to represent known functional relationships. Dimensional analysis can be of great help in each instance. Students of science use this method of approach on many of their daily problems. Is the method restricted only to science? Could it be used in the public schools and colleges? These and other questions will be discussed after additional introductory remarks.

From the original introduction of dimensional equations by Fourier to the recent embrace of dimensional theory by Einstein, many scientists have contributed to the enrichment of the field. Notable among these was Maxwell, who was the first to use the theory extensively.

The basic dimensions are length (L), mass (M), and time (T). One may define the dimensions of any quantity as a mathematical expression of the form $L^{\alpha}M^{\beta}T^{\gamma}$, where α, β and γ are exponents to be determined. The equality of two such dimensional expressions constitutes a dimensional equation.

Dimensions must obey the following rules:

(1) Only like dimensional quantities may be added or subtracted.

(2) The dimensions of products or quotients are the same as the product or quotient of their separate dimensions treated as algebraic quantities. It is principally through this law that dimensional equations are set up and from which new formulae may be developed.

(3) The two sides of an equation *must* always have the same dimensions. The equality of dimensions provides a useful test of the accuracy as well as of the plausibility of mathematical work.

There are some quantities, such as angles, temperature, and all relative magnitudes, which do not depend on the above-mentioned basic dimensions and therefore are considered to have the dimension of 0.

(*See table on the following page.*)

Dimensional analysis is used quite extensively for converting from one type of unit to another and for checking equations of definition. However, its great potential for the development of new formulae is only recently being tapped. Its use is not at all restricted to science but has extensive applications in everyday life. It can also be a key

The following is a brief table of dimensions:

TABLE I

Quantity	Dimension
Length	L
Mass	M
Time	T
Area	L^2
Volume	L^3
Velocity	LT^{-1}
Acceleration	LT^{-2}
Gravity	LT^{-2}
Density	$L^{-3}M$
Force	LMT^{-2}
Work	L^2MT^{-2}
Power	L^2MT^{-3}

instructional aid for the teaching of all subjects demanding the use of meesurements.

II. Dimensional Analysis in Action

Suppose one wishes to convert 100 miles to meters. First, multiply 100 miles by the ratio

$$\frac{5280 \text{ ft.}}{1 \text{ mile}}$$

This ratio is unity. In this product the mile dimensions are eliminated and the conversion of 100 miles to 528,000 feet is complete. Continue the process of multiplying by unit ratios and eliminating unwanted units until the remaining unit is meters. The completed conversion is exemplified as follows:

$$\cancel{100 \text{ miles}} \frac{5280 \cancel{\text{ft.}}}{1 \cancel{\text{mile}}} \frac{12 \cancel{\text{in.}}}{1 \cancel{\text{ft.}}} \frac{2.54 \cancel{\text{cm.}}}{1 \cancel{\text{in.}}} \frac{1 \text{ meter}}{\cancel{100 \text{ cm.}}} = 159{,}934.4 \text{ meters}$$

Additional examples would be easy to supply.

Consider the formula for total force on a plane surface submerged in a given liquid.

$$F = \int_a^b whldh.$$

See Fig. 1. Let us check to see if the formula is dimensionally correct. The dimension of F—LMT^{-2}—is stated symbolically as follows: $[F.] = LMT^{-2}$. Then $[h] = L$, $[l] = L$, and $[dh] = L$. The symbol w stands for the weight per unit volume of the liquid. Then

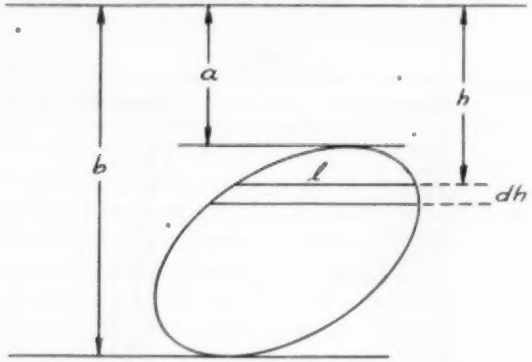


FIG. 1

$[w]=L^{-2}MT^{-2}$. The following dimensional equation can now be set up: $LMT^{-2}=(L^{-2}MT^{-2})(L^3)=LMT^{-2}$. Therefore, since the identity is established, the given equation is dimensionally correct.

Suppose now we discuss the simple pendulum problem. The units are indicated in Fig. 2. The problem is to find the time it will take the pendulum to swing from P_1 to P_2 and return to P_1. This time is

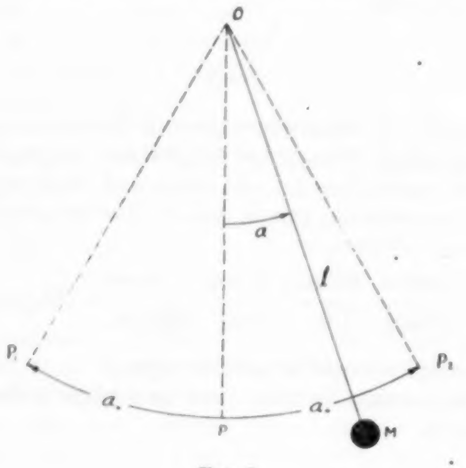


FIG. 2

called its period. Observations indicate that the period T depends on length of the pendulum, gravity, and the angle α. We therefore, write down the following relationship: $T=f(1, g, \alpha)$. $[T]=T$. $[g]=LT^{-2}$. α is of dimension O. From physics we can write the following: $T=\Sigma A_{pqr}\alpha^p l^q g^r$, where A is a constant and p, q, and r are exponents

to be determined. From this we write the dimensional equation $T=L^q(LT^{-2})^r$, and $T=L^{q+r}T^{-2r}$, therefore $q+r=0$ and $-2r=1$ and $r=-\frac{1}{2}$ making $q=\frac{1}{2}$. Then $T=\Sigma A\alpha^p l^{1/2} g^{-1/2}$ or $T=\phi(\alpha)\sqrt{l/g}$. $\phi(\alpha)$ can be determined mathematically to be 2π and it can be experimentally verified. The complete formula, then, is $T=2\pi\sqrt{l/g}$.

Now let us consider the problem of finding centripetal acceleration. A mass m (in fig. 3) is being whirled about center O with radius R. After some thought one concludes that acceleration depends only on

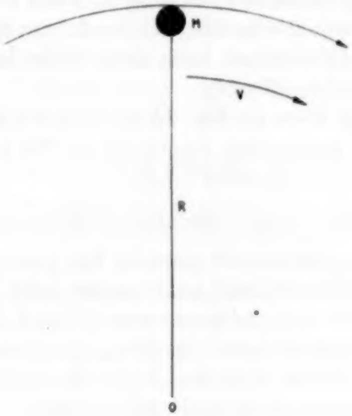


FIG. 3

the radius and velocity v. We therefore write $a=f(R, v)$ and $a=\Sigma A_{\alpha\beta}R^\alpha v^\beta$. The resulting dimensional equation is $LT^{-2}=L^\alpha(LT^{-1})^\beta = L^{\alpha+\beta}T^{-\beta}$, making $\alpha+\beta=1$, $-\beta=-2$, $\beta=2$, and $\alpha=-1$. Then $a=K(v^2/R)$. K can be determined experimentally to be 1.

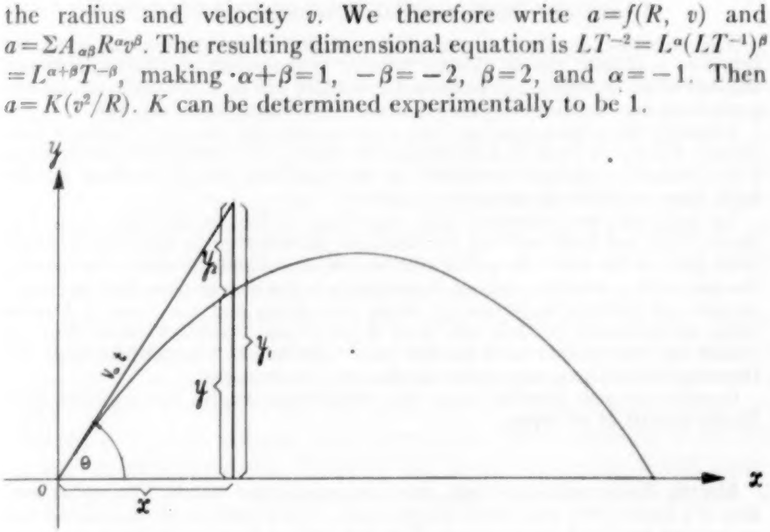


FIG. 4

One more example should suffice. The problem will be to develop the parametric equations of the path of a projectile. Fig. 4 gives all of the necessary information. From the figure we observed that x depends on v_0, the initial velocity, and time t, and we can write $x=f_1(v_0, t)$. One can observe that y is of the form y_1-y_2, where y_1 depends on v_0 and t and y_2 depends on gravity and time. To find the x relationship, observe the accompanying dimensional triangle in Fig. 4. Cos $\theta=x/v_0t$ or $x=v_0t\cos\theta$. Likewise, $y_1=v_0t\sin\theta$. $y_2=f_2(g, t)$ and can also be expressed as $y_2=\Sigma K_{\alpha\beta}g^\alpha t^\beta$. Then $L=(LT^{-2})^\alpha(T)^\beta$, and $L=L^\alpha T^{\beta-2\alpha}$. So $\alpha=1$, $\beta-2\alpha=0$, and $\beta=2$. $y_2=Kgt.^2$

To evaluate K differentiate both sides of the latter equation with respect to t. Then $d^2y_2/dt^2=2kg$.

Since $d^2y_2/dt^2=g$, then $g=2kg$, $2k=1$, and $k=\frac{1}{2}$.

The final set of parametric equations for the path of a projectile is: $x=v_0t\cos\theta$ and $y=v_0t\sin\theta-\frac{1}{2}gt^2$.

III. Some Concluding Remarks

This paper has pointed out some of the problems of science the solution of which dimensional analysis can play an important role. Certain rules were stated and terms were defined. Dimensional analysis was applied to conversions, checking equations of definition, and the development of new formulae. Only the future will reveal what new frontiers dimensional analysis will conquer.

BUILDING NEW GANDER AIRPORT AND TOWN

This important northern air terminus is getting its first permanent wave. By this time next year, the old Gander familiar to thousands of Allied airmen and millions of air travelers, will be gone. In its place will be a new air terminal and a spanking new Gander town that is already resembling Suburbia, U.S.A.

Although the airport here has been a permanent one, the town has been temporary. Unique in Canada, and perhaps the world, Gander's 5,000 population is a one-income community—aviation. As one Ganderite put it, "without the airfield, there would be no excuse for Gander."

Up until this year everyone and everything in Gander has been housed in bleak, stark and drab war surplus. Barracks, have served as apartments; recreation halls as the bank, the police station, the school and the stores. All is being changed with a total face-lifting. So complete is the change-over that the entire complex of miliatry buildings are being torn down and the town of Gander being moved bodily one-half mile west of the airport boundary. More than 150 houses and apartments have already been built by the Central Mortgage and Housing Corporation, responsible for the new development.

Gander last year handled more than 400,000 passengers and approximately 12,400 aircraft of all types.

Electric Etcher will mark iron, steel and most other metals. The etcher consists of a heavy duty step-down transformer, a work plate, a ground clamp and an etching tool held like a pencil. The tool utilizes a tungsten point that does not stick or weld to the work.

INTEGRATED LEARNING AS A RESULT OF EXERCISES IN MATHEMATICS AND SCIENCE

WILLIAM H. PAYNE
Hammond Technical Vocational High School, Hammond, Ind.

INTRODUCTION

The relationship between science and mathematics makes integrated learning[1] of the two subjects desirable. Organization of the two subjects prior to classroom application is desirable since learning should be preplanned experience. A plan is presented that shows the organization of mathematics concepts and exercises which can be related to 8th grade science for integrated learning.

JUSTIFICATION FOR INTEGRATED LEARNING

Integrated learning as a result of exercises in mathematics and science provides the students with (1) a chance to apply mathematics outside of the mathematics classroom and, thus, perceive a need for mathematics and (2) a learning experience that requires recall of mathematics and science to work each exercise. The use of these two subjects for integrated learning is desirable because (1) both subjects have been developed by exact observation and are similar in nature and (2) the history of both fields indicates development through combination or union.

ORGANIZATION FOR INTEGRATED LEARNING

Mathematics is to be applied in science. Organization of the two subjects should be done prior to application in the classroom. This organization provides the teacher with a planned procedure for applying mathematics in science. If the teacher fails to organize the subjects, many chances to apply mathematics concepts may be overlooked. Organization enables the teacher to see which concepts might be combined more readily. Not only will a plan aid the teacher in the classroom process, but it will also provide a written record to which she can refer for making valid test questions.

Table I is a suggested form which could be followed by the teacher in combining mathematics with 8th grade science for integrated learning. The table organizes mathematics concepts or topics with a science unit dealing with the solar system. The sub-topics in the "Science Topics" column were determined by examining seven 8th grade science texts and choosing the most commonly listed topics. The items in the "Mathematics Topics" column were chosen as

[1] Integrated learning—the learning act in which mathematics and science concepts are necessary for the solution of exercises in science.

partial answers to the problem stated below each set of topics. The "Procedure" shows one way in which the answer to the problem could be applied in the classroom. The exercises are coded to refer to the mathematics sub-topics that are required for a correct response. Example: Exercise 1.8 bg requires the student to know the relationship $C=\pi d$ and $d=2r$; i.e. he must understand mathematics topics b and g to get the answer.

TABLE I

A SUGGESTED FORM TO COMBINE MATHEMATICS AND 8TH GRADE SCIENCE FOR INTEGRATED LEARNING

Science Topics	Mathematics Topics	Procedure	Exercises
Size and shape of the earth and its comparison to other members of the solar system.	a) diameter b) radius c) circumference d) sphere e) oblate sphere f) π (pi) g) formula h) comparison by ratio i) cooparison by division	Define diameter, radius, circumference in relation to the earth. Determine value of π by measurement of various circles or spheres and form ratios C/D to find the value π. Show to be a constant. Relate to earth measurements and arrive at formula $C=\pi d$. Show $d=C/\pi$. Define "formula" and show use. Explain comparison of sizes of two objects by division and ratio.	1.1 g* 1.2 c 1.3 a 1.4 d 1.5 f 1.6 g 1.7 ag 1.8 bg 1.9 ih 1.10 c 1.11 e 1.12 h
Problem: How can mathematics be used to explain the size and shape of the earth and to compare its size with other planets and the sun?		*Answer:* Mathematical terms such as diameter, radius, sphere, and circumference will ai' in describing the shape and size of earth and other solar bodies. Comparison of size can be done by division or by forming ratios	
Position and movement of the earth in the solar system	a) concentric circles b) scale drawing c) use of drawing compass d) reading and writing large numbers e) light year (distance) f) rounding numbers g) mean distance h) elliptical	Define concentric circles and relate to solar system. Have students use compass and draw 9 concentric circles about a point (sun). Hold up several before the class to show need of scale drawing. Suggest 1 inch = 1 million miles for scale and get response. Let class decide scale that all will use for home project—a neatly drawn solar system to scale. Review reading and writing large numbers. Find how many miles in one light year. (Round to nearest trillion). Review rounding numbers. Define elliptical and show what is meant by mean distance.	2.1 ah 2.2 g 2.3 b 2.4 g 2.5 h 2.6 d 2.7 e 2.8 2.9 g 2.10 e 2.11 b 2.12 bc 2.13 a 2.14
Problem: Can mathematics be used to define the position and movement of the earth in the solar system?		*Answer:* Mathematics can be used to quantitatively describe and geometrically define the relative position and movement of the earth in the solar system.	

* Numbers refer to exercises in list which are related to mathematics topics as indicated by the letter.

EXERCISES

1.1 g At the equator how many times farther is it around the earth than through it?

1.2 c Another word which means "the distance around the earth" is (1) radius (2) circle (3) sphere (4) circumference (5) diameter

1.3 a A word which means "the distance through the earth" is (1) radius (2) circle (3) sphere (4) circumference (5) diameter

1.4 d The word which most correctly defines the shape of the earth is (1) radius (2) circle (3) sphere (4) circumference (5) diameter

1.5 f Because the symbol π always has a value of $3\frac{1}{7}$ it is called a (1) radius (2) circle (3) variable (4) circumference (5) constant

1.6 g If the earth contracted, the diameter would be less. The circumference would be (1) the same (2) greater (3) less (4) variable

1.7 ag If the diameter of the earth is 8000 miles, what is its circumference?

1.8 bg If the radius of the earth is 3850 miles, what is its circumference?

1.9 ih How does the earth compare in size with the sun? with Mars? with Saturn?

1.10 The circumference of a certain reflecting mirror is $628\frac{4}{7}$ inches. What is the diameter of the mirror? Is this mirror located at Mount Wilson?

1.11 e The best geometric term which describes the earth is (1) radius (2) sphere (3) ball (4) oblate spheroid

1.12 h What is the ratio of the earth's diameter to that of Jupiter?

2.1 ah What is meant by the "earth's orbit"?

2.2 g What is the distance from the earth to the sun?

2.3 b In a scale drawing 1 inch equals 1 million miles; what would be the approximate diameter of the circle representing the earth's orbit on this drawing?

2.4 g If the mean distance from the earth to the sun is 93 million miles, what is the mean diameter of the earth's orbit?

2.5 h The shape of the earth's orbit is (1) round (2) oblong (3) elliptical (4) oblate spheroid

2.6 d Using arabic numbers write the distance two trillion five hundred ten billion miles, which is the distance to the nearest star?

2.7 e T or F. A light year is a measure of time.

2.8 What is the speed of the earth in its orbital travel? Hint: find C from $C = \pi d$.

2.9 g The moon's closest approach to the earth is 221,000 miles away and its furthest approach to the earth is 253,000 miles distant. What is the mean diameter of the moon's orbit around the earth?

2.10 a Light travels nearly six trillion miles in one year. Sirus, the brightest star, is $8\frac{1}{2}$ light years distant. How many miles is Sirus from the earth? (use arabic numbers)

2.11 b In making a scale model of the moon, sun, and earth, you choose a ball 2 inches in diameter for the earth. How large a ball would you need for the moon? for the sun? How far apart would they be from each other during a lunar eclipse?

2.12 bc Draw circles to represent the sizes of the planets. Make a circle for Mercury $\frac{1}{4}$ inch in diameter. Using a table of facts about the solar system, figure diameter and draw circles to the nearest tenth of an inch which would represent the other planets on the same scale.

2.13 a Which planet takes the longest to make one complete revolution about the sun? Why?

2.14 Light travels 186,000 miles per second. How many minutes does the light from the sun take to reach the earth? At sunrise, how long is the sun above the horizon before you see it? Think!

Summary

Mathematics and science are subjects favorable for integrated learning because of their similar nature. Organization of the two subjects should be done p ior to application. Organization should combine both subjects such that learning requires recall of both mathematics and science concepts for the solution of one exercise.

Invitation for Criticism

Any criticisms or new ideas regarding the combination of mathematics and science at any grade level are solicited. Send your suggestions to William Payne, Hammond Technical Vocational High School, Hammond, Indiana.

PAIN-KILLER PROTECTS HEART FROM JITTERS

A shot of pain-killer directly into the heart will protect that organ from a deadly jittering state during frozen sleep anesthesia. The technique has been developed by Dr. Leo R. Radigan of the National Heart Institute here and in parallel research by Dr. Angelo Riberi at Indiana University, Bloomington, Ind. More than 40 patients have already benefited from the new technique. The pain-killer used by Drs. Radigan and Riberi to prevent fibrillation at such a time is novocain, familiar as the pain-killer the dentist uses.

REVIEW OF RESEARCH RELATED TO THE TEACHING OF ARITHMETIC IN THE UPPER ELEMENTARY GRADES

FRANCES PIKAL
Lincoln School, Kalamazoo, Michigan

THE PROBLEM

It is the purpose of this article to review the research since 1940 dealing with the teaching of arithmetic in the upper elementary grades. The studies chosen for review were selected on the basis of areas of arithmetic taught in the fourth grade. However, many of the studies reviewed in this article were undertaken in grades other than the fourth.

METHODS EMPLOYED

The reviewer searched through the *Education Index*, through bibliographies (4, 7, 12, 17) of a number of reviews of research on mathematics, and also through Monroe's (8) *Encyclopedia of Educational Research* to obtain the 12 studies in this review.

The studies have been arbitrarily grouped into the following categories: research related to method of teaching, research related to arithmetic concepts learned and used outside of school, research related to the subtraction process, research related to the division process, research related to the relationship of reading to achievement in problem solving, and research related to remedial arithmetic.

RESEARCH RELATED TO THE METHOD OF TEACHING

How does the meaningful functional approach to arithmetic compare with the traditional method? Much educational theory taught in college points to the value of the experience type curriculum. Seldom is this supported by studies. Therefore, the reviewer found studies related to the significance of method that were done since 1940. There were those of Williams (16) and of Harding and Bryant (6). Williams (16) undertook to determine the mathematical learning which took place in 9 successive sixth grade groups (1935 through 1944) under the experience curriculum. She used the Stanford Achievement Tests in arithmetic and compared the results "with the grade norms standardized for an entirely different type of curriculum." Harding and Bryant (6), in a similar study, used 64 fourth grade pupils. They also used the Stanford Achievement Tests and anecdotal records were kept for the experimental group to determine results which were compared with the results of a control group utilizing the drill method. The results reveal that the children in the experience curriculum con-

sistently scored higher in the reasoning test rather than in the abstract examples test, although the experience curriculum was effective in developing computational skills. Analysis of the standardized test scores in both studies reveal that the experience type of curriculum proved more effective than following the textbook method.

Is difficulty rating of addition facts related to the method of teaching? Swenson (13) used 332 second grade children to determine "the relationship between method of learning and the difficulty rating" of the 100 addition facts. Each of the pupils were assigned to a group which were taught by one of these three methods: (a) drill, (b) generalization, or (c) drill-plus. Timed tests were given at the beginning and at the end of the experiment. Percentages of difficulty were computed for each fact. From the statistics obtained she "concluded that the comparative difficulty of addition facts is to some extent influenced by the method used in teaching."

The studies by Williams (16), Harding and Bryant (6) and Swenson (13) indicate that the method of teaching arithmetic has significance. Although Swenson in her article did not attempt to determine which method was best, the studies carried out by Williams (16), and Harding and Bryant (6) did.

Research Related to Arithmetic Concepts Learned and Used Outside of School

How do children use arithmetic outside of school time? Arithmetic concepts that are maintained through use outside of school have special significance for the teacher inasmuch as these areas are useful and meaningful to the student. Ellsworth (2) in his study of 390 children of the 3rd through 6th grades, on the uses which children find for numbers, used a combination questionnaire-pupil reporting type of procedure. The results were tabulated and percentages were figured for the frequency of occurrence of each tpoic. The results show that the first four highest percentages of usage (on telling time, using U. S. money, counting, and reading numbers), represented over 66% of the entire frequency. Another significant finding was that the four fundamental processes of whole numbers are necessary and, therefore, 100% efficiency should be required of the students. "Use of fractions seems to be limited and mainly confined to those children who are interested in practical arts." Therefore, with these findings in mind, this study appears to be of special significance for curriculum committees.

What time concepts do children have at various grade levels? Since telling time is the major arithmetical activity carried on outside of school, as pointed out by Ellsworth (2) and since time concepts are developed outside of school to a large extent, there is, apparently, a

great need for calling to the teacher's attention the problems concerned with the child's background of time concepts. Friedman (3) carried out an investigation involving 697 pupils from kindergarten through Grade VI to determine what the time concepts held by children are. The results from the tests indicated that children's concepts of time increase with their increasing maturity. To support this statement he found that "by the time pupils reached Grade VI, they had a satisfactory comprehension of our time system." He also, found that the primary child's concepts of "long time ago" and "short time ago" were directly related to the child's own personal experience.

The previous studies, by Ellsworth (2) and Friedman (3), indicate areas of child living related to time concepts that can be incorporated easily into the school arithmetic program.

Research Related to the Subtraction Process

What is the best method of teaching subtraction? At least 15 studies have been done to determine which of these two subtraction methods, the equal additions method (EA) or the decomposition method (D), produces the best results. Two recent studies, one by Rheims and Rheims (11) and one by Brownell (1) have attacked this problem in a different manner. Rheims and Rheims used 35 pairs of students selected from two Jr. High Schools to determine the value of the respective methods, 5 years after the processes had been taught. From the results of the testing it was concluded that for the less intelligent group the decomposition method was superior, whereas the results of the research did not favor significantly one method over the other for the more intelligent group.

Brownell (1) attacked the problem of determining which process, the (EA) method or the (D) method, was best by using 328 third grade students who had not been introduced to "borrowing" subtraction. "The groups were matched in respect to C.A., M.A., I.Q., and rate and accuracy in computation." These were divided into 4 experimental groups (1) the decomposition, mechanical, (2) decomposition, rational, (3) equal additions, mechanical, (4) equal additions, rational. In this study, "he confirmed the superiority of (EA) over (D) when both are taught mechanically but he favored the teaching of 'borrowing' by (D) rather than (EA) when (D) is taught rationally, and when understanding and ability to transfer are regarded as important learning factors."

It is difficult to control all of the factors in research to determine which subtraction method is best. Therefore, the factor of initial learning experience may have some bearing upon the results determined by Rheims and Rheims (11). Brownell (1) recognized that another factor must be considered before the decision is made as to

which is best. He pointed out that there should be some investigation to evaluate our educational objectives.

Can pupils learn how to use the ten in subtraction successfully by using a self-instruction method? Some arithmetic textbooks caution the teacher to move from the concrete to the abstract in teaching arithmetic. This process was reported in a study done by Wilburn (15) in which he used 291 third grade pupils in 12 schools in learning to use a ten in subtraction. In evaluating the success of this teaching procedure, he concluded that on the whole most of the students had learned to use the ten meaningfully, although the 6 weeks' period of instruction was apparently not long enough for some of them to raise their level of using a ten to one of "thinking" entirely.

The three studies just reported upon indicate that there is still much research needed in this area.

Research Related to the Division Process

At what grade level could a readiness program for division start? Since the division process seems to be difficult for some children to grasp, it has been the tendency to develop it later in the curriculum. However, two studies, one by Osburn (9) and one by Gunderson (5) seem to shed new light on the placement of division.

Osburn (9), after analyzing the errors made by students over a period of 20 years, arranged division problems in their order of sequence from simple to complex into 41 levels of difficulty. He concluded that "long division is a whole series of abilities ranging from very easy to very difficult." Some division "is easy enough to be learned in Grade II." Gunderson (5) came to a similar conclusion in her study. She used the interview method on 24 second grade children to determine their thought-patterns when confronted with multiplication and division problems. In this study she, also, arrived at the conclusion that second grade is not too early to lay the foundation (in meaning) by means of concrete objects, for division, inasmuch as all but one of the students solved the problems correctly.

It, apparently, seems logical that since meaning is stressed in today's teaching that the concrete stage of the foundation for the division process could be begun during the second grade. Each successive level of difficulty, as Osburn (9) mentioned, could be taught after the youngster has mastered the previous level of difficulty.

What is the best method to determine the quotient in long division? Another topic of debate and study is the use of trial divisors. Osborn (9), in the study in which he tabulated the levels of division difficulty, also, made a study of the quotients. Since 61% of all the long division problems used in living, have quotients which are "apparent" he

recommends that that method be taught to the beginner in long division rather than the estimation method.

These studies on division (9, 5), although not completely conclusive, indicate that a foundation for division could be made before the fourth grade.

Research Related to the Relationship of Reading to Achievement in Problem Solving

What are the reading skills that have relationship to the ability of the child to solve arithmetic problems? Story problems sometimes present difficulty to some children. Therefore, this study by Treacy (14), to determine the relationship of certain reading skills to the ability to solve verbal problems in arithmetic, is of value to the arithmetic teacher. In this study Treacy (14) collected 18 items of information for each of 244 7B pupils in 2 Milwaukee Jr. High Schools through the administering of a group of 15 tests to determine the many facets of problem-solving and reading abilities. The results of this study indicate that teachers should consider the reading skills which are significantly related to success in this subject. The author found that "four of the reading skills on which good and poor achievers in problem solving differed significantly were associated in one way or another with vocabulary." "Good and poor achievers differed significantly on Retention of Clearly Stated Details." This suggests that students having difficulty with problem solving may also be troubled with ability to retain significant facts.

Research Related to Remedial Arithmetic

In remedial arithmetic, do problems of personal adjustment effect achievement in arithmetic? Plank (10) conducted an investigation by means of observation on 5 children that were retarded from 3 to 14 months in arithmetic. These children appeared to be maladjusted as indicated by an investigation of school records, interviews with parents, and observations by the author. A group of tests were given to the youngsters and as a remedial measure, the Montessori mathematical materials for elementary schools was used. One of the conclusions reached from this study was that the achievement in arithmetic seemed more strongly related with problems of personal adjustment rather than with intelligence or school experience. However, "the results of the investigation are valuable mainly in that they show a direction for further study under more favorable conditions."

Summary

The studies reviewed in this paper have significant implications

for the upper elementary teacher in the following areas: the method of teaching arithmetic, the concepts of arithmetic children use outside of school, the methods of subtraction and division, the social aspect of arithmetic, and the remedial aspect of arithmetic.

Significant implications for the upper elementary teacher determined from the results of the studies reviewed are many and varied in nature. The experience type curriculum seems to be more effective than the traditional method in teaching arithmetic. The major areas of arithmetic that children use outside of school are in: (a) telling time, (b) using U. S. money, (c) counting, (d) reading numbers. The teacher can build on the time concepts children form outside of school. With the present objectives of education in mind more research needs to be carried out to determine which subtraction method is best. If the curriculum committees follow the suggestion of research the foundation for division can be meaningfully introduced in the second grade. By the fourth grade there would have been a good background of meaning built. The teacher can understand that some of the difficulties children have with problem solving are because of the vocabulary and because they have difficulty retaining the stated details of the problem long enough to solve the problem. Perhaps difficulty with arithmetic may be strongly related to problems of personal adjustment rather than with intelligence or school experience.

Further studies need to be done in various areas covered in this review as suggested previously in this paper.

Bibliography

1. Brownell, Wm. A., "An Experiment on 'Borrowing' in Third Grade Arithmetic." *Journal of Educational Research*, XLI (November 1947), 161–171.
2. Ellsworth, Elmer, E., "Number Experiences of 390 Children from Grades 3–6 in an Urban Area." *Education*, LXI (April 1941), 485–87.
3. Friedman, Kopple C., "Time Concepts of Elementary School Children." *Elementary School Journal*, XLIV (February 1944), 337–42.
4. Gibb, E. G., "A Review of a Decade of Experimental Studies Which Compared Methods of Teaching Arithmetic." *Journal of Educational Research*, (April 1953), 603–8.
5. Gunderson, A. G., "Thought-Patterns of Young Children in Learning Multiplication and Division." *Elementary School Journal*, LV (April 1955), 453–61.
6. Harding, Lowry W. and Bryant, Inez, "An Experimental Comparison of Drill and Direct Experience in Arithmetic Learning in a Fourth Grade." *Journal of Educational Research*, XXXVII (January 1944), 321–37.
7. Hightower, H. H., "Effect of Instructional Procedures on Achievement in Fundamental Operations in Arithmetic." *Education Administration and Supervision*, XL (October 1954), 336–48.
8. Monroe, Walter S., *Encyclopedia of Educational Research*. New York: The Macmillan Co., 1950, Pp. xxxvi+1520.
9. Osburn, W. J., "Levels of Difficulty in Long Division." *Elementary School Journal*, XLVI (April 1946), 441–47.

10. PLANK, EMMA N., "Observations on Attitudes of Young Children Toward Mathematics." *Mathematics Teacher*, XLIII (October 1950), 252–63.
11. RHEIMS, G. B. AND RHEIMS, J. J., "A Comparison of Two Methods of Compound Subtraction: The Decomposition Method and the Equal Additions Method." *Arithmetic Teacher*, II (October 1955), 63–9.
12. SHERER, L., "Some Implications from Research in Arithmetic." *Childhood Education*, XXIX (March 1953), 320–4.
13. SWENSON, ESTHER J., "Difficulty Ratings of Addition Facts as Related to Learning Method." *Journal of Educational Research*, XXXVIII (October 1944), 81–5.
14. TREACY, JOHN P., "The Relationship of Reading Skills to the Ability to Solve Arithmetic Problems." *Journal of Educational Research*, XXXVIII (October 1944), 86–95.
15. WILBURN, D. BANKS, "Learning to Use a Ten in Subtraction." *Elementary School Journal*, XLVII (April 1947), 461–66.
16. WILLIAMS, CATHERINE M., "Arithmetic Learning in an Experience Curriculum." *Educational Research Bulletin*, XXVIII (September 14, 1949), 154–168.
17. WRIGHTSTONE, J. W., "Influence of Research on Instruction in Arithmetic." *Mathematics Teacher*, XLV (March 1952), 187–92.

SHELL COMPANIES FOUNDATION PLANS MORE FELLOWSHIPS FOR HIGH SCHOOL TEACHERS

Expanded aid to outstanding high school physics, chemistry and mathematics teachers—with an eye to their encouraging more students to study the subjects and thus help check the nation's growing shortage of scientists—was announced by Shell Companies Foundation, Inc.

The Foundation this year provided Shell Merit Fellowships for 60 high school teachers at seminars conducted by Stanford and Cornell universities this past summer.

M. E. Spaght, president of the Foundation and executive vice president of Shell Oil Company, said, "The first year's program was so successful that we plan to provide a significantly greater number of fellowships for 1957."

More than 2,000 teachers from all parts of the United States applied for the Fellowships available in 1956. Fellowship teachers received allowances for travel costs to Stanford or Cornell, tuition fees, living expenses and $500 in cash to offset loss of potential summer earnings.

Dr. Paul DeH. Hurd, coordinator of the program at Stanford, said teachers at the West Coast Seminar "felt the chance to study recent developments in science and education and the opportunity to become acquainted with outstanding scientists in their fields made the seminars one of the most exciting experiences in their careers."

Dr. Philip G. Johnson, coordinator of the Cornell Program, said, "The high school science and mathematics teachers in the first Shell Merit Fellowship Seminar will be significant centers of influence for improved science and mathematics teaching in our secondary schools. Their efforts will undoubtedly aid and inspire many other teachers."

Requests for Fellowship applications should be sent directly to the two universities. Teachers living west of the Mississippi should write the School of Education, Stanford University, Stanford, California. Teachers east of the Mississippi should write the Department of Education, Cornell University, Ithaca, New York.

Mathematics, physics or chemistry teachers with five years' experience and known leadership ability will be eligible for the fellowships.

FIELDSTON'S KADA OBSERVATORY

GEORGE R. DARBY
Fieldston School, Fieldston Road, New York 71, N.Y.

The second astronomical observatory in New York City—the only other is Columbia University's—will be opened for use this month at the Fieldston School in the Riverdale section of New York City. Fieldston is one of the three Ethical Culture Schools of New York City, which also include the Fieldston Lower School in Riverdale and the Midtown School at 33 Central Park West. An independent school attended by more than 600 boys and girls, Fieldston is one of very few secondary schools in the United States to have its own observatory. This year, as a result, our students of the 11th and 12th grades are eligible for a course in astronomy which is being given by Henry M. Neely, special lecturer at the Hayden Planetarium, editor of *The Sky Reporter*, and author of many books on astronomy, including his recently published *The Stars by Clock and Fist.*

Our observatory is a hexagonal building thirteen feet high to the top of its revolving dome, which has a diameter of twelve feet. It houses a Newtonian type telescope with an 8″ objective mirror, a fine instrument with a multiplying power in the neighborhood of 250 diameters.

The school owes its unusual good fortune to the skill and generosity of Eugene Kada, who first made the telescope and then built the observatory in which it is mounted. Mr. Kada is one of those rare amateurs whose professional training is perfectly adapted to the pursuit of his hobby. He is by trade a designer of fine precision instruments and tools. For the past few years he has spent whatever time he could spare from the important task of building our observatory in designing and making precision lenses and optical instruments.

But it is as an amateur astronomer that he began his career in telescope making. As far back as he can remember the stars have fascinated him. When the Hayden Planetarium first opened in New York City in 1935 he attended the first lecture given by its director, the late Dr. Clyde Fisher, who founded the Planetarium's Amateur Astronomers' Association. A new world of activity opened up for Mr. Kada. He joined the amateur group, and became a member of the small, select circle of enthusiasts concerned with the study and making of telescopes. For the past eight years he has been a special consultant on mirror grinding and polishing for the Planetarium's course in telescope making.

Besides helping other people to make telescopes, Mr. Kada himself has made several. One of his first attempts was a 6″ instrument which he brought nearly to completion. When an accident spoiled his care-

fully ground mirror, he expressed his discouragement by setting to work on an 8" telescope almost twice as powerful. It is this instrument, begun in 1937 and finished eight years later, which is now housed in Fieldston's new observatory.

While Mr. Kada was working on this telescope, he was putting in a full work week designing and making precision instruments. His weekends were spent in the shop planning and working out the details of his pet project. When it was finally completed and assembled in the hall bedroom where he was living at the time, the beautiful monster hardly left him room to turn around in. Seven feet long, it weighed almost 200 pounds.

Mr. Kada was somewhat at a loss to know what he should do with it. He felt that such a fine instrument deserved a good home where it would be put to use and well cared for. While he was casting about in his mind for a suitable recipient, he decided to move to California.

The telescope was dismantled and shipped to Los Angeles. While Mr. Kada was living there Dr. Henry Neumann, leader of the Brooklyn Ethical Culture Society, came to lecture at the University of California at Los Angeles. As a lifelong member of the Brooklyn Society Mr. Kada had known Dr. Neumann for some years. He had also known of the Fieldston School, which is administered under the auspices of the Ethical Culture Society of New York City. He asked Dr. Neumann whether he thought Fieldston would be interested in having his telescope. When his suggestion was referred to us, we were of course delighted to accept the offer, since the largest telescope we had was a portable 6" instrument.

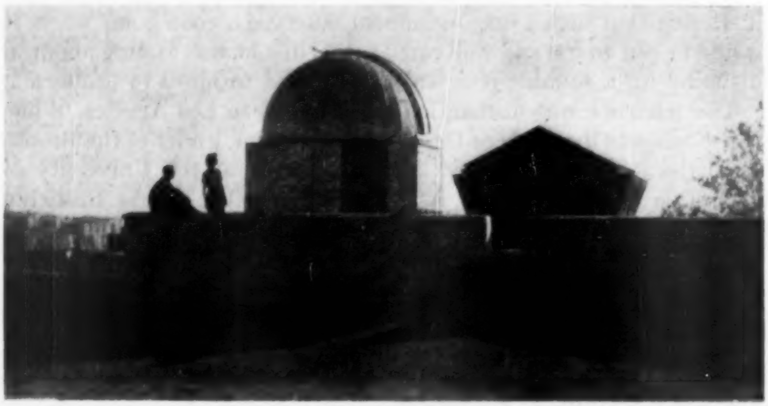
In 1950 Fieldston became the owner of Mr. Kada's telescope. Then the problem arose as to how we could best put it to use. Mr. Kada had returned to New York City, so we asked him to visit the school and give us his advice on the matter. He agreed with us that it would be impossible to get full benefit from the telescope without an observatory in which it could be permanently mounted. So without further ado Mr. Kada offered to build us an observatory if the school could find a suitable location. We thought first of the roof of the science building as the logical spot, but about that time we were projecting the addition of a new auditorium building on our campus. The flat roof of this modern structure, we soon realized, would make an ideal site for an observatory. As it turns out, it is the highest geographical point in any of the boroughs of Manhattan, Brooklyn, Queens, or the Bronx.

When this building was completed in 1953 Mr. Kada drew up plans and set to work. The cost of materials and some carpentry work on the hexagonal foundation was met from funds donated by the Fathers' and Sons' Association of the school. Mr. Kada did the major part of

the work himself in his spare time, including the construction of the motorized revolving dome. So exactly was the project executed that the motor used to turn it needed to be only one-fortieth horsepower.

The dome is built on a frame made of ¾" plywood ribs attached to a ring base made of 2"×6" pieces bolted together. The 2"×6" wood was used in preference to boards because it does not warp as they are apt to do. For the roof Johns Mansville's *Transite* was used. Being thermally inactive it is ideal for the purpose. Asphalt tile was laid over masonite to make a durable, easily cleaned floor.

A clock drive on the telescope keeps it in balance, while the opening in the dome is synchronized with the movement of the telescope.



High above the city's smog, the Fieldston School Observatory, in the Riverdale section of New York City, sits atop the roof of the auditorium building. (Photo by G. R. Darby.)

The telescope itself has a 64" focal-length mirror. In its construction Mr. Kada utilized an idea of his own to facilitate cleaning of the primary mirror. At that end of the scope he has constructed a detachable cell which through the use of collimation can be easily removed and put back in exactly the same place. The special construction of the cell makes the usually difficult chore of cleaning the mirror very much simpler.

Mr. Kada has also made an improvement over the usual system employed by most amateur telescope makers of using rotation rings on the saddle of the scope. This telescope is fixed on its axis, and the observing end rotates periscope-wise when it is in use.

Still another ingenious device introduced by the designer is the use of radium paint to illuminate the cross-hairs of the finder. Four small dots of luminous paint, one in each section of the finder, serve as further guide to the observer.

A sidereal clock will pace the telescope's motor, compensating for the rotation of the earth. Another piece of equipment which we shall add as soon as possible is an electronic photometer to measure the varying brightness of a star and plot it on a perfect curve. With the naked eye, even with many readings, it is impossible to achieve a smooth unbroken curve of intensity measurements.

The Fieldston School is in an especially happy situation with regard to its ability to put this splendid equipment to good use. Located on a hill which lies between the city and its suburbs, our spacious campus is free from the obstructions of tall buildings and from the glare of city lights which handicap astronomers in Manhattan. The atmosphere in our area is also much clearer than that of the midtown section with its smoke and fumes.

Starting with Mr. Neely's course, which he is giving for the second year as a guest member of the faculty of the Fieldston School Arts Center, the Kada Observatory and its telescope will give our science students a rare opportunity to begin the serious study of astronomy before they enter college. The Arts Center is one of several media through which our school projects its program into the community. It offers courses in literature, the arts, woodworking and astronomy to adults on two weekday evenings and to children on Saturday mornings. The astronomy course, in which Mr. Neely is assisted by Herbert Bassow of our science faculty, was opened this year to our own eleventh- and twelfth-grade students. We hope to add an astronomy minor to our regular curriculum next year.

A number of students may become members of the Association of Variable Star Observers, and we hope that their studies of the variation, timing and magnitude of stars may add to the sum total of knowledge being accumulated by that interesting international organization. Meanwhile Mr. Neely is teaching his young students to become so familiar with the use of the nautical almanac that they may predict what will appear in the sky at any time. By the end of the year he expects that the boys in his class will be qualified for acceptance by the Navy and Air Force for special training as navigators.

A crew of amateur photographers under the direction of Mr. Bassow will take photographs of the sun on clear days so that a record of sun spots may be preserved. It is even possible that with luck we may get a glimpse of one of the man-made satellites which will be released during the International Geophysical Year which starts next July.

Through all these activities our students not only will gain for themselves experience that will help them in their future science study, but also will be able to make some contribution, however

small, to the aggregate of scientific knowledge. Even more important we believe, is the effect which the study of astronomy will have on their whole view of life. One of the student members of Mr. Neely's class wrote recently, after seeing for the first time the great Andromeda nebula:

"At first the sight of this unimaginably huge and distant galaxy made me fee that I and mankind were insignificant, lost ornaments in the universe. However, as the days went by following this thrilling evening and I continued to ponder man's insignificance, it occurred to me that, while we may be small in relation to the universe, we are highly significant in that we can even be aware of our situation and ponder it.

"Today I am still awed, now by both the sheer magnitude of the universe . . . and by the fantastic notion that somewhere in it some part of it can question its own existence. My thinking . . . though by no means unique or original, is still of immeasurable importance to me, and it all stems from those 15 or 20 seconds . . . when into my eye came light which had traveled almost a million years."

We hope that by means of the Kada observatory many more of our students may receive an introduction to the mysteries of the Universe that will make them eager to keep on trying to understand and explain them. If this proves true, Mr. Kada's patience and devotion will have been well repaid.

FEDERAL FUNDS FOR EDUCATIONAL RESEARCH

The Office of Education, U. S. Department of Health, Education, and Welfare, today announced approval of the first two contracts for cooperative educational research in its history.

The contracts, with Indiana University and with Vanderbilt University, will be financed from a recent appropriation of $1,020,000 for research by colleges, universities, and State agencies in the problems of education. Several other projects are under active consideration.

Indiana University will undertake an 18-month research project to determine why capable high school students in the State of Indiana do not continue their schooling.

Dr. Wendell W. Wright, Vice President of Indiana University, with Christian W. Jung, Associate Professor of Education and Director of the University's summer session, will direct the Indiana research project.

Research will be undertaken to determine the reasons why only one-fourth of the top 10% of Indiana's high school graduates in 1954–55 entered college. Also studies will be made to learn how many of the top 20% of the State's 1955–56 high school graduates do not continue their educational programs into college, and why they do not.

The Office of Education has allocated $15,900 in Federal funds for the project. About one-third of the cost will be provided by Indiana University.

Vanderbilt University will conduct, under the direction of Dr. Albert J. Reiss, Jr., a three-year-study of causes of juvenile delinquency.

The study will be made among children in the grades 7 through 11 in Nashville and in Davidson County, Tenn., with the cooperation of public, private, and parochial schools, and community agencies. Information will be solicited from teachers, parents, attendance officers, juvenile court officials, and other citizens.

Federal funds totaling $49,060 are planned for the Vanderbilt project.

A DEVELOPMENT OF A MATHEMATICAL EXPRESSION FOR THE LIQUIDATION OF AN INDEBTEDNESS BY A CONSTANT ARBITRARY PAYMENT p

Ethelbert W. Haskins
Prairie View A. & M. College, Prairie View, Texas

Purchase by deferred financing has long since become an integral component of Americanism. The price of most of our commonplace conveniences are such that, without some extra sacrifice, the average family cannot pay by cash for these at the time of initial possession. Moreover, we are psychologically attuned to using the commodity during the payment interval—ride as you pay, as it were.

In this connection it is pretty universally understood that, theoretically, if there is left after the down payment an outstanding debt of k-dollars which must be liquidated over n payment periods, unless some variations are imposed, the payment p varies. This payment p becomes smaller each month because it is in part the interest on the principal, including that portion toward whose liquidation its application applies.

Consider an indebtedness of \$1,200 at 6% interest which is supposed to be paid off in 2 years by way of 24 monthly installments. The first payment will be \$50 plus the interest for that month on \$1,200. That is $p_1=\$50+\$6=\$56$ at the end of the first month. The second payment p_2 will equal \$50 plus the interest for one month on \$1,150. This interest is \$5.75, so $p_2=\$55.75$. In the same manner p_3 will equal \$55.50, p_4 will be fifty-five dollars and twenty-five cents, etc. This p will continue diminishing by 25¢ until finally p_{24} will equal \$50.25.

There are various methods for paying debts of this nature. For example the order of the p_n's may be reversed so that the payments will increase rather than decrease. Again the p_n's could be totalled and divided by the number n (n equals 24 in this example) so that all the payments are equal. That is, for every p,

$$p=\frac{\sum_{n=1}^{24} p_n}{24}.$$

A third variation could be the case in which a debtor felt himself unable to pay more than a flat payment of \$50 each month. In this instance only \$44 of the first payment would go toward the liquidation of the principal because \$6 of this amount would be the interest

on \$1,200 for the first month. Out of the second payment of \$50, \$44.22 would be the amount by which the principal is diminished because \$5.78 would be required to take care of the interest on \$1,156 for one month.

Out of each subsequent payment the amount going toward the liquidation of the principal would become progressively larger because this principal (and thus the interest) is becoming increasingly smaller. It is apparent however, that the debt could not be settled in 24 months because the entire \$50 is not being used toward its liquidation.

The obvious questions that this example poses are:

a) How many months would it take to liquidate this debt?
b) How much would the last payment amount to?
c) How much of the \$50 on, say, the tenth payment would go toward settlement of the principal?

It is quite evident that the amount credited to the principal could be laboriously calculated month by month, where the kth payment could be reckoned from the $(k-1)$th payment, starting from the first month. Finally, the last payment will have been arrived at when the remaining principal plus the interest on this remainder is fifty dollars or less.

The development of a general mathematical expression for the liquidation of any amount of indebtedness D, by a constant arbitrary payment p, is the purpose of this article.

The indebtedness at the time the first payment falls due is

$$D_{b1} = P + Prt,$$

where t is the time-period between payments, and the subscript $b1$ means *before the first payment*. An $a1$ would mean *after the first payment*, etc. Factoring P in the right-hand side of the equation, and remembering that t equals one between payments, the equation becomes

$$D_{b1} = P(1+r). \tag{1}$$

After the first payment the indebtness is

$$D_{a1} = P(1+r) - p. \tag{2}$$

By the time the second payment is due the indebtedness is

$$\begin{aligned} D_{b2} &= [P(1+r)-p] + [P(1+r)-p]rt, \\ &= [P(1+r)-p](1+r), \end{aligned} \tag{3}$$

and after the second payment

$$D_{a2} = [P(1+r)-p](1+r) - p. \tag{4}$$

Further,

$$D_{b3} = \{[P(1+r)-p](1+r)-p\} + \{[P(1+r)-p](1+r)-p\}rt,$$
$$= \{[P(1+r)-p](1-r)-p\}(1+r),$$
$$= [P(1+r)^2-p(1+r)-p](1+r),$$

that is

$$D_{b3} = P(1+r^3-p(1+r)^2-p(1+r), \tag{5}$$

and

$$D_{a3} = P(1+r)^3-p(1+r)^2-p(1+r)-p. \tag{6}$$

Moreover

$$D_{a4} = P(1+r)^4-p(1+r)^3-p(1+r)^2-p(1+r)-p. \tag{7}$$

Then the indebtedness after the kth payment is

$$\begin{aligned} D_{ak} &= P(1+r)^k-p(1+r)^{k-1}-p(1+r)^{k-2}- \cdots \\ &\quad -p(1+r)^2-p(1+r)-p, \qquad (8)\\ &= P(1+r)^k-p[(1+r)^{k-1}+p(1+r)^{k-2}+ \cdots \\ &\quad +(1+r)^2+(1+r)+1], \\ &= P(1+r)^k-p[1+(1+r)+(1+r)^2+ \cdots \\ &\quad +(1+r)^{k-2}+(1+r)^{k-1}], \end{aligned}$$

and by summing the series in the last expression of the above equation

$$D_{ak} = P(1+r)^k-p\left[\frac{1-(1+r)^k}{1-(1+r)}\right],$$

and in a more compact form

$$D_{ak} = P(1+r)^k-\frac{p}{r}\left[(1+r)^k-1\right]. \tag{9}$$

The indebtedness before the kth payment can be expressed as

$$D_{bk} = D_{ak}+p = \left\{P(1+r)^k-\frac{p}{r}\left[(1+r)^k-1\right]\right\}+p,$$
$$= P(1+r)^k-\frac{p}{r}(1+r)^k+\frac{p}{r}+p,$$

and finally

$$D_{bk} = P(1+r)^k-\frac{p}{r}[(1+r)^k-(1+r)]. \tag{10}$$

A substitution of $k+1$ for k in (9) gives

$$D_{a(k+1)}=P(1+r)^{k+1}-\frac{p}{r}[(1+r)^{k+1}-1], \tag{9a}$$

and the validity of (9*a*) may be tested by the following method (mathematical induction). Knowing that $D_{a(k+1)}=D_{ak}(1+r)-p$, we have

$$D_{a(k+1)}=\left\{P(1+r)^{k}-\frac{p}{r}\ [(1+r)^{k}-1]\right\}(1+r)-p,$$

$$=P(1+r)^{k+1}-\frac{p}{r}(1+r)^{k+1}+\frac{p}{r}(1+r)-p,$$

$$=P(1+r)^{k+1}-\frac{p}{r}\left[(1+r)^{k+1}-(1+r)+\frac{r}{p}(p)\right],$$

that is

$$D_{a(k+1)}=P(1+r)^{k+1}-\frac{p}{r}[(1+r)^{k+1}-1]\ \cdot \tag{9b}$$

Since (9b) is identical to (9a), giving (9a) validity, we may now generalize that the indebtedness after any nth payment can be expressed as follows:

$$D_{an}=P(1+r)^{n}-\frac{p}{r}[(1+r)^{n}-1], \tag{11}$$

and that the indebtedness before the nth payment, that is, at the time the nth payment is due, is

$$D_{bn}=P(1+r)^{n}-\frac{p}{r}[(1+r)^{n}-(1+r)]\ \cdot \tag{11a}$$

From (11) it is obvious that, when $D_{an}=0$; when the debt has been paid

$$P(1+r)^{n}=\frac{p}{r}[(1+r)^{n}-1]\ \cdot \tag{12}$$

To find the number of payments required to liquidate the debt, we may solve for n in (12), which, after certain elementary algebraic operations gives

$$(1+r)^{n}=\frac{p}{p-Pr},$$

then, by taking the logarithm of both sides, and solving for n, one has

$$n=\frac{\log\dfrac{p}{p-Pr}}{\log(1+r)}. \tag{13}$$

Formula (13) lends itself to certain interesting observations some of which we will consider here. Take the case when $Pr=p$. This makes $p/(p-Pr)$ infinite, which in turn makes n ihfinite. The practical interpretation of the case is that, if the payment is no greater than the interest (Pr), the debt will remain outstanding forever. On the other hand, if $p-Pr>0$ by any amount no matter how small, then n is finite. Meaning that if the payment exceeds the interest even by a small sum, one can in time look forward to the liquidation of the debt. Again, consider the case where $r=0$. For this purpose one may write (13) in the form

$$n=\frac{\log p-\log(p-Pr)}{\log(1+r)}.$$

At $r=0$,

$$n=\frac{\log p-\log p}{\log 1}=\frac{0}{0}.$$

This is an indeterminate, but by l'Hospital's Rule

$$\lim_{r\to 0}\frac{\log p-\log(p-Pr)}{\log(1+r)}=\lim_{r\to 0}\frac{\dfrac{d}{dr}[\log p-\log(p-Pr)]}{\dfrac{d}{dr}[\log(1+r)]};$$

$$=\lim_{r\to 0}\frac{-\dfrac{\log e}{p-Pr}(-P)}{\dfrac{\log e}{1+r}}=\frac{P}{p},$$

that is,

$$n_{r=0}=\frac{P}{p}. \tag{14}$$

From (14) one sees that if the rate is zero—which means there can be no interest— the number of payments required for the liquidation of the debt is the amount of the indebtedness divided by the amount of the payment.

To find what portion of some nth payment p is required for interest, and what portion is applied toward defraying the principal, one has only to remember that the indebtedness after the $(n-1)$th payment subtracted from the indebtedness before the nth payment equals the interest that has accured since the $(n-1)$th payment. Thus

$$A_{ni}=(D_{bn}-D_{a(n-1)}), \tag{15}$$

where A_{ni} is the amount of the nth payment taken for interest, and

$$A_{nP}=p-(D_{bn}-D_{a(n-1)}), \tag{16}$$

where A_{nP} is the amount of the nth payment applied to the principal. And certainly the sum of (15) and (16) equals p (the payment).

Perhaps it would be interesting, in conclusion, to apply this development to the solution of questions (a), (b), and (c) of our practical example at the beginning of this article.

Solutions:

(a) By (13),

$$n=\frac{\log \dfrac{50}{50-1200\ (.005)^{*}}}{\log 1.005}=\frac{.055516}{.002166},$$

$$=25.63 \text{ or } \mathit{26\ months}—$$

where the last payment will equal

(b) $D_{a25}+D_{a25}(r)=.63(50)+.63(50)\ (.005)=\$\mathit{31.66}$

(c) From (16), where n equals 10

$$A_{10P}=p-(D_{b10}-D_{a9})$$

$$=50-\left[\left\{1200(1.005)^{10}-\frac{50}{.005}\ [(.005)^{10}-(1.005)]\right\}\right.$$

$$\left.-\left\{1200(1.005)^{9}-\frac{50}{.005}\left[(1.005)^{9}-1\right]\right\}\right]$$

$$=50-(800.32-796.08)$$

$$=\$\mathit{45.76}$$

* 6% interest per year is .05% interest per month.

CONSERVATION OF ONE TEACHING RESOURCE

B. Clifford Hendricks
Longview, Washington

"I had an undergraduate major in college science. My first high school teaching was with classes in that field. Even so, I find it necessary to *limit* registration in those courses in this high school. Why? Because teachers competent to teach them are not to be had." This was the parting confession of a high school principal to Doctor Harry James, Professor of Physics of Hastings College, and the writer. He had just served as host for our inspection of his new ultra-modern high school building.

Doctor Harold Wise, for many years supervisor of science teaching in the University of Nebraska Training High School, now Assistant Dean of the Graduate College, says, "During recent years it is becoming increasingly apparent . . . that . . . the United States is experiencing a critical shortage of scientists and engineers."[1] He suggests that "if boys and girls can be enrolled in science and mathematics courses while in high school . . . and . . . be taught by capable and inspiring teachers (they may) be lead to (favor) careers in fields of pure and applied sciences."

American Chemical Society President, J. C. Warner, speaks similarly in his editorial of the October 1956 *Journal of Chemical Education*. He says, "The key to the problem (of supply of trained scientists and engineers) consists in providing gifted (students with instruction) under competent and inspiring teachers."[2]

As in that new high school, so elsewhere, there is a dearth of those "capable and inspiring teachers." Doctor Wise becomes more explicit when he continues, "The number of qualified teachers of science and mathematics has fallen off fifty-three per cent in the past five years while the high school student body has increased sixteen per cent and continues to go up."

In the face of this evident need various agencies have proposed ways and means toward its alleviation. Fellowships for summer conferences for science and mathematics teachers, career guidance booklets for high school students by industries, federal appropriations to help improve high school teaching of science and mathematics are but a few of the many.

A cooperative Committee of the American Association for the Advancement of Sciences was organized in 1941. Buttressed by a $300,000 grant from the Carnegie Foundation, it has set up a seven

[1] Harold E. Wise, "Science Education: In a Slump," *Nebraska Alumnus*, June, 1956, p. 16.
[2] J. C. Warner, Editorial for October 1956, *Journal of Chemical Education*, p. 481.

point program. One of its proposals is to provide consultants for high school teachers of science and mathematics. This is upon the assumption "that many persons now teaching high school science and mathematics are not well prepared in subject matter." To further this proposal "pilot studies" are currently under way in four areas in which qualified persons are helping a limited number of needy teachers or school executives in either subject matter or on administrative problems having to do with high school science or mathematics.

This counselling, it is thought, will "up grade" the quality of the instruction and facilitate the utilization of visual and laboratory aids for the schools involved. "It (is) assumed that a teaching counsellor or consultant, operating entirely without administrative authority, could tutor, assist and serve as a source of information to the less-experienced and probably less-competent science teacher."[3]

Doctor Wise finds eight respects in which such counselling might render helpful services. The prime objective of all, however, is to induce a greater interest of a greater number of high school and college students in science and mathematics. In scanning his proposals a very understandable query arises, "Whence the counsellors?"

The most immediate answer to that, no doubt, is, "From the 'cream of the crop' of science and mathematics teachers already in service." But if these "pilot studies" become more numerous their demand for counsellors will further reduce the already inadequate "stock pile" of teachers for those subjects.

A second suggestion is, "Make the remuneration for such counsellor service so attractive as to draw persons from industrial jobs." But in using those persons there is the hazard that they may not be, either by inclination or previous training or experience, qualified for effective service in such a setting.

That which follows is venturing to propose a third source for the personnel needed: The "Senior Citizens of America" are becoming increasingly numerous. In 1952 there were 13,000,000 of them.[4] Of those millions of men and women, aged sixty-five or above, fourteen per cent were unemployable.[5] That says that eighty-six per cent *were* "able to perform their regular duties." What per cent of those "employables" had been teachers of science and mathematics is not stated. However, it is not unreasonable to think that in that group there is a sizable reservoir of persons who were retired from teaching those subjects.

---

[3] Harold E. Wise, *ibid.*, p. 28.

[4] Fact Book on Aging, Committee on Aging and Geriatrics, Federal Security Agency, Washington, D. C., p. 1.

[5] Fact Book on Aging, p. 3.

There are services which those "retired" people can perform in the current teacher shortage:

1. By a more *intelligent* program, of high school and college teacher retirement processing, many of them should still be teaching after the usual retirement age. If that were so their replacement teachers would be available to staff the added classes which our rising high school enrollment is demanding.

2. There is an increasing interest in college and even in high school undergraduate research. This is especially evident in projects set up to minister to the enriched programs for students of "above-average" abilities. (These students, by-the-way, are especially sought for careers in science and mathematics.) Success in undergraduate research depends much upon the teacher or counsellor who serves as a resource person for the student investigator. The relationship here is more that of person to person rather than the person to class situation in class room teaching. The older member of the pair would here find that certain of his qualifications that reduced his usefulness in the class room are not a handicap in these personal encounters. In such a relationship he would find an appreciative student *responding* to his "stock pile" of experience and information.

3. These teachers, older grown, who may no longer be effective or comfortable in the classroom, may be useful in the "pilot studies" mentioned above. For the same reasons, previously considered, they would have much to offer as consultants of either science teachers or of school executives seeking to improve their schools for participation in the upgrading of interest of students in science and mathematics.

It is very possible that there would be *more* than fourteen per cent of the "chronologically retired" unemployable for effective participation in any of the above roles. However, screening procedures for their identification should not be difficult. To that end much modification of present practice in choosing faculty folks for "emeritus status" would have to be achieved.

One proposal[6] intimates that the pattern of integrating a high school student into his freshman college program is suggestive. It pointed out that just as the high school student's interests, abilities, deficiencies, previous preparation and even personal quirks are rather objectively assessed so those pertinent personal assets and liabilities of the "emeritus-to-be" should be objectively inventoried. Just as the high school student who is deficient in English has his registration for a foreign language deferred so the older teacher whose speaking voice is on the decline would be scheduled for small class groups to the mutual advantage of all. In other words, those defi-

[6] "Retired or Recapped?" *Science Teacher*, March 1954, p. 52.

ciencies that prompt administrators to "retire" a teacher would be catalogued and ways of objectively identifying and evaluating them developed. The chronological age of the high school student is disappearing from the list of items considered at the time of his entrance into the college. Should there not also be an acceleration of the growing conviction that chronological age is a false criterion for the severance of teachers from their professional status? True, the time criterion is very convenient; to be more objective would require a departure from patterns that have long been in use. There would come a need for attention not only to those qualities that come with age that are hinderances but, quite as important, equal attention to the positive that are assets to be conserved. (Maybe in this program, of a more objective assessment of "time for retirement," the older, already-retired, folks may find a chance for another valedictory service.)

Without waiting for this "more intelligent" retirement procedure, some aspects of it may be considered in the light of the topic in hand. From casual observation some handicaps of the aging teacher may be listed. Among them are: slower reaction time, decreased sharpness of sense perception, unbalanced recourse to long past memories, forgetfulness and decline in vocal control. And, by-and-large, the older person has less personality appeal than the younger teacher. These deficiencies are of considerable concern when class room service is in focus. However, as previously mentioned, most of them become of lesser import when the student group involved becomes fewer in numbers. In situations where it is a "person to person" conference most of them are almost negligible.

In conclusion: it is to be noted that placement of the "senior citizen" in the high school class room has not been proposed. In situations where there is the informal relations of the conference type it is reasonable to think the older teacher would perform with a minimum of handicap. For the student who is "up against it" in his research or the teacher or executive with a pressing need the age or the idiosyncrasies of the "one who knows" will not be a hindering block to the conference. In consequence, does it not appear that among those millions of employables of America's "Senior Citizens," there may be found some help for this emergency? Is it in order to think of this as the "Conservation of One Teaching Resource?"

Self-Filling Pen operates automatically by use of a capillary unit. The pen is filled by removing the barrel top and dipping the exposed inner cell into the ink bottle. It has no filling lever, tube, ink sac or cartridge. One 10-second filling will last for six hours of steady writing.

An intense hour will do more than dreamy years.—Beecher

THE TECHNICAL MANPOWER SHORTAGE

RUTH W. WOLFE
Taylorstown, Pennsylvania

I. THE NATURE AND SIGNIFICANCE OF THE PROBLEM TO BE ATTACKED

The literature of the day, popular as well as scientific and professional, bewails the manpower shortage. This is a shortage of highly trained scientists to run our highly mechanized world and to develop better and more powerful machines. There is an even greater shortage of trained technicians to perform the simple operations (1). And behind all this shortage is the shortage of qualified teachers of science and mathematics, who are needed to prepare future scientists, engineers, teachers, and other professional people.

As Rear Admiral H. G. Rickover (12) points out, it is industrial power that makes political power among the nations. and industrial power depends upon the scientific and engineering professions. These professions depend upon a continuous flow of capable and well-trained persons. The race for survival in industrial and therefore in political power depends on having each individual in our country achieving his maximum opportunity for education and training.

Factual proof of the shortage is found in the fact that "Uncle Sam" is raising his bid for science and engineeering graduates (4). The Civil Service Commission offers a premium rate to 1956 B.S. and M.S. graduates. B.S. graduates start at $4,480; M.S.'s at $5,335. Each of these is $180 above top starting pay in non-technical fields. To attract physicians the U. S. offers M.D.'s $7,465 or $1,070 more than last year.

"Now the 'Cold War' of the Classroom" is the headline of an article in the *New York Times* (11). It points out that in Russian schools in grades 5–10 about 40% of the student's time is allotted to science and mathematics. He must take algebra, geometry, and trigonometry. Also required are 4 or 5 years of physics, 4 years of chemistry, 2 years of biology, 1 year of astronomy, 1 year of psychology, and 6 years of foreign language. There is no freedom of choice, and as another author points out (12), although there may be a lack of general culture, the Russian engineer is trained as well as or better than ours. Russia is passing us in the rate at which she is increasing her scientific and engineering talent, while her rate of attrition is lower because of the lower age at which her workers are ready to start practical work.

Our mass production still allows us to build more than Russia, but with her increasingly larger number of scientists, she may produce some who can build better than we can or do (12). Khrushchev re-

cently said, "We don't have to fight. Let us have peaceful competition and we will show you where the truth lies.—Victory is ours."

II. Diagnosis of Causes, Showing the Responsibility of the Mathematics Teacher

The technical manpower shortage seems to be due to three main causes: (a) the technological revolution, (b) the enlarging human needs, and (c) the failure of schools to meet the demands.

The technological revolution has brought about a change in the type of employee industry needs. More skilled workers are needed. Now out of 64 million American workers only a mere 9 million have definite skills. Also the majority of these skilled workers are in "classic" trades such as building and machinery. There are relatively few in the newer fields of electronics and aviation (1). The need for engineers is great, but for each engineer 5 skilled technicians are needed (10). These technicians do not need a college degree, but they do need mathematics to or beyond the present top high school level.

Ever enlarging human needs follow technological improvements. Each individual wants to acquire or use all the new devices. These give him more leisure to desire, invent, and acquire greater mechanical aids. Americans have doubled their standard of living every 40 years since 1880, at the same time reducing the workweek from 65 hours in 1880 to 40 hours in 1953. This is the same as if each citizen were given 60 mechanical slaves to work for him, or as if there were a technical population of $7\frac{1}{2}$ billions (14, 9). This might appear to cut down rather than increase the need for technicians. What actually happens is a chain-reaction of improvement requiring more research scientists to produce new ideas, more practical scientists and engineers to develop designs and procedures for useful applications, and more technicians to actually build, operate, and maintain these mechanical slaves.

And just how have the schools failed to meet these growing needs for the mathematically trained? In the first place, the number of qualified teachers of science and mathematics in the United States has dropped 53% in the past five years, and during the same time the enrollment has increased 16% (16). The number of teachers being prepared for high school teaching has declined, and even more, those prepared to teach mathematics (8). Not more than half of those prepared for teaching go into the profession. Again the manpower shortage with its "inflationary" salaries draws these potential and active teachers into industry.

The educational crisis also involves "quality" of teaching, says Rickover (12). Since we cannot match Russia's manpower in num-

bers, we will have to continue to surpass her in quality. The length of the school year in the United States has doubled since 1870; the proportion of teachers to pupils is greater; the cost of education in elementary and high school is 9 times as much (even with the changed value of the dollar considered); but the quality is really very little better.

In interviews with over 1,000 college graduates in 10 years, Rickover's conclusion is that they lack motivation. They use college as a "service station on the road to security—security in terms of money, rather than in opportunity for self-improvement." They know facts but not principles, and principles are the important thing, for facts are changing so rapidly that no college can keep up with them. Rickover says this failure is not the fault of educators alone but of all the people in not recognizing the impact of the 20th century revolution.

III. A Constructive Proposal: Who Should Do What and How?

That something has already been accomplished in at least increasing the number of engineers is evident. Data from the United States Department of Health, Education, and Welfare indicates a "New Boom in Graduate Work" (3). The article points out, however, that the high salaries paid have made the men so eager to get to work that fewer go on to do graduate work of the doctoral level. Since the companies want these high level men too, they are in many instances sending the highly talented on to school. They are asking universities to set up more off campus centers so men can go on working and attend school too. To some extent this has not worked well, as the hours of work and study together are too long for the best results.

Another report (15) shows that engineering enrollment is increasing each year more rapidly than the total male enrollments and in spite of a diminishing total population of college-age males.

In order to accelerate the training of scientists and engineers, an experiment was carried out at Rensselaer Polytechnic Institute (Troy, New York) by Arthur A. Burr (13). Ten brilliant juniors from ten colleges worked six weeks to reach the level normally required of graduate students. At least half made it, and all but one merited 6 credit hours of graduate work. Burr believes that 5–10% of the nation's engineering juniors could do without the senior year and thus become productive sooner and have an opportunity to reach higher levels. If this assumption is correct, it means that between one and two thousand manpower years could be saved by the simple expedient of acceleration of gifted engineering students alone. If this idea were

extended to other associated scientific and mathematical fields, this amount of potential power increase might be doubled or even tripled.

In the experiment at Rensselaer Polytechnic, the students were given full-tuition scholarships, and travel and living expenses. This suggests that one of the chief needs in meeting the problem of the shortage is financial help. Among the many suggestions for financial help is recognized "duality of support" (12, 16): federal and local government; public and private philanthropy; donations from labor as well as from industry. A further suggestion is that, instead of individual scholarships allocated by any one of these groups, the funds be assigned to a central group of men not directly connected with either school or industry; so that no group will be accused of trying to control the schools. Money should be spent for new buildings to relieve the crowded conditions at present existing and to meet the expected increase in enrollment. Rickover says, however, that he thinks more in proportion should be spent on getting better teachers than on getting better schools. He points out that while it takes two years or less to build a school, it takes four years to train elementary and high school teachers and seven or eight years to train college teachers. A "drastic" increase in teachers' salaries is also suggested in order to attract and hold teachers of greater ability and higher training and to secure better work from many who now divide their interests between school and other jobs.

There is also the idea that industry use part of its funds in granting sabbatical leave for scientists and engineers to teach in the schools (12). Such a suggestion certainly discounts the value of the teacher's professional training. It would seem that a better program for the mathematics teacher would be to enlist the aid of representatives from business and industry in presenting the facts of the shortage to the public, in inspiring and helping to select students for scientific and mathematical work, and in providing literature and visual aids to improve classroom instruction.

During the war it was demonstrated that adults could be taught more quickly and efficiently by pictures (films, slides, etc.) than by lectures. The motivation of audio-visual aids is usually great to bright students as well as to slow-learners.

Benton suggests that technology be brought into the classroom (11). The use of films and television makes available to all the services of the best teachers. He thinks it would make it possible for one teacher to handle 200–300 pupils instead of 30. Such procedures would require great care in execution and would certainly be restricted in use to advanced students and to special subjects. Even in the elementary schools, however, films could be used much more exten-

sively if more projectors were provided (5), and television being used in schools in some of the larger cities is available in surrounding rural areas, if they could have receiving facilities. Thus could be provided the enrichment necessary to challenge the gifted child and to lead him into discovery of his interests and talents. It is further suggested (5) that for small high schools unable to sponsor all necessary science courses, integrated courses of the correspondence type could be developed. Sound films could be prepared and tested by experts at some central point. Lists of supplementary reading, workbooks, laboratory experiment kits, and tests could be supplied. These lessons could also be televised in order to reach students with ability who had dropped out of school.

Even with lots of money, wonderful facilities, and well-trained teachers, the entire program will fail if the pupils are not properly guided into the available courses. It is thought that testing for aptitude should begin in 5th or 6th grade or sooner (5). Sixth grade children are preparing to enter junior high school, and even though they may have few elective courses there, it is good for them to at least start thinking about the course of study and life work they want to follow. Such testing should secure the interest of parents of gifted children and lead them to encourage the efforts of the child and the school toward enrichment and possible acceleration of the child's program both in school and outside. The testing should also help the teacher in her effort to direct, enrich, and motivate her program. And the test results together with the pupil's marks and the teacher's general evaluation, will serve the administrator in planning the curriculum and placing the students to the best advantage. "Ability is not like gold, which unmined is still valuable, but like a plant needing to be tended all the time." As long as administrators, teachers, parents, and the child himself do not *know* he has ability (or lacks it) little effort is likely to be made to develop all his potential power to its greatest extent; and capable children held back too long may lose interest, while the slow-learner who is "pushed" too fast may become completely discouraged. Various types of counselors as librarian, visual education director, and guidance counselor may be used to acquaint and interest students in the scientific and mathematical fields. In order to discover talented students in these fields, Westinghouse puts on its annual Talent Scouts Program in which this year 20,828 high school students participated. This contest not only results in the discovery of potential scientists and mathematicians but inspires more earnest studying and more efficient teaching.

According to a recent report (17) efforts to meet the needs of the technical manpower shortage and to improve the functioning of the

mathematics department of the high school have led to three basic attempts to revise the curriculum.

In the first of these the idea is to do away with the tight compartments into which algebra, geometry, and trigonometry have been placed. This new arrangement takes the important topics of mathematics as they are found in these and other branches of mathematics and develops them in a "natural" and unified manner. This is supposed to have the advantage of making the mathematics more "functional" and to improve retention, as skills gained in one branch are not neglected while studying another. Since many colleges still require definite certification in the traditional subjects for entrance, this plan has not yet been very widely accepted.

Another plan is to put into the high school at least some topics from the college level of analytic geometry, statistics, and calculus. This would accelerate the preparation of engineering students and offer the extra training needed for certain technical jobs.

The third system is the multiple-track. It has been suggested that one track be for the gifted who can be greatly accelerated and achieve the work indicated in the second plan outlined above. Another track could take care of the normal academic group who do not expect to be scientists or mathematicians. Still another track would be in general mathematics. This would be for the non-college student and would attempt to prepare for the mathematical needs of everyday living. It would include social and economic problems presented in real life situations and should extend through the entire school period. Finally, a fourth group would include those slow-learners in need of special remedial work. All of these tracks should be flexible enough to permit passage from one to another.

It is also stated (17) that the "big need is for comprehensive research" concerning the learning process in mathematics, the pupil, the teacher, and the curriculum. Some fundamental changes are needed if the general population is to become "mathematically literate"; and as they are revealed by the educational profession, the public should see that they are made possible by supplying the funds and by supporting the administration in executing them.

In conclusion, what can and should the individual teacher do to help alleviate the technical manpower shortage?

1. Secure adequate personal training.
2. Help in the selection and guidance of students for scientific and mathematical work.
3. Discover and use all available facilities to interest and instruct the students.
4. Enlist the interest and help of community leaders in business, industry, labor, government, school administration, service organizations, and P.T.A.

Bibliography

Business Week

1. Apr. 16, 1955—Shortages of Skills
2. May 5, 1956—Colleges Share Students with Industry
3. May 26, 1956—New Boom in Graduate Work
4. June 2, 1956—Uncle Sam Raises His Bid for Science and Engineer Graduates

California Journal of Secondary Education

5. May 1955 —New Approaches to Old Problems

Industrial Arts and Vocation Education

6. Apr. 1956 —Westinghouse Talent Scouts
7. Apr. 1956 —Counseling

Mathematics Teacher

8. Oct. 1955 —Where Do Eligible Mathematics Teachers Go?
9. Dec. 1955 —Mathematics and the Technical Manpower Shortage
10. May 1956 —Effective Mathematics in Industry

New York Times

11. Apr. 1, 1956—Now the "Cold War" in the Classroom

School and Society

12. May 26, 1956—The Situation in American Engineering and Scientific Education
13. May 26, 1956—Acceleration in Training Scientists and Engineers

School Life

14. Jan. 1955 —The Technological Team
15. Apr. 1956 —Engineering Enrollments and Degrees

Science

16. May 25, 1956—United States Technical Education

Educational Testing Service

17. 1956 —Problems in Mathematical Education

Mathematics Teacher

18. Dec. 1949 —The Certification of Teachers of Mathematics

$300,000 AWARDED FOR STUDENT FELLOWSHIPS IN 1956–57

Advanced study abroad as Rotary ambassadors of good will is the assignment of 122 outstanding graduate students from 32 countries for the 1956–57 school year. These young men and women are the recipients of fellowships awarded by Rotary International, world-wide service club organization, as one of its contributions toward the goal of promoting international understanding, good will and peace.

Since the program was inaugurated in 1947 as a memorial to the founder of Rotary, Paul P. Harris, Rotary Foundation Fellowships have been awarded to youths living in 61 countries for study in 40 countries. The one-year, all-expense fellowship grants average $2,500 each and, for 1956–57, amount to approximately $300,000. Total grants since 1947 are in excess of $2,000,000.

WISCONSIN SCIENTISTS GO TO ANTARCTICA

University of Wisconsin geophysicists are readying for the long treks which will carry them to Antarctica in the gigantic, earth-searching program known as the International Geophysical Year. The year is set once every 20 years or so—this time for 1957–58—and the nations of the world cooperate in carrying out the studies.

Dr. George P. Woollard, who heads the geophysics section of the University's geology department, said that men from Science Hall on the Madison campus will ultimately be active on four fronts, including the Arctic and Antarctic, in the international program to examine the earth, top to bottom, and inside and out.

Launching of the earth satellite is one of the objectives for IGY. Inquiry will include such widely diversified subjects as glaciers, oceans, the northern lights, weather, cosmic rays, the upper atmosphere, longitude and latitude, the sun's activities, and gravity and seismic phenomena.

The Wisconsin men, either on their own or in parties, will be applying the principles of physics and mathematics to the science of geology, measuring changes in physical quantities, particularly in relation to the earth's crust.

Edward Thiel, Wisconsin Ph.D. from Wausau, John Behrendt, UW master of science, fiom Marinette, and James A. Weiman, UW assistant in physics left the campus in November for work on glaciers in the Weddell Sea. They will work out from an American base on this east coast of Antarctica, doing gravity and seismic measurements. Thiel and Behrendt expect to be gone for at least a year.

Leaving about the same time as Thiel and his companions were Instructor John Rose, and Robert Iverson, junior, Oregon, Wis. They will work in Australia for a month and then, by ice-breaking ship and "hitchhiking" with the U.S. Air Force, will try to reach the pole. They will conduct their gravity measurements from a base on McMurdo Sound, west coast of Antarctica. Return date is set for next February.

Planning to be gone for a year or more, Ned Ostenso, Wisconsin master of science alumnus from Chippewa Falls, left Madison Nov. 23 to join a Columbia University party headed for Marie Byrd Land. Ostenso will do gravity, magnetic, and seismic studies in this northwestern area of Antarctica.

Hugh Bennett, Wisconsin bachelor of science, the last of the men to leave in the 1956 schedule, left in early December to join a party from the Cambridge (Mass.) Research Center. The group will operate from Little America, west coast of Antarctica, the base from which Admiral Byrd accomplished his South Pole victory. Bennett will probably also be gone a year on the gravity, magnetic, and seismic studies.

Dr. Woollard, who directs Wisconsin's contribution to IGY, set up the program of gravity studies for the 40-nation science project. Early in October he flew to England to deliver there the delicate measuring instruments for a British IGY party. The English group includes Sir Edmund Hilary, who succeeded in scaling Mount Everest in May, 1953.

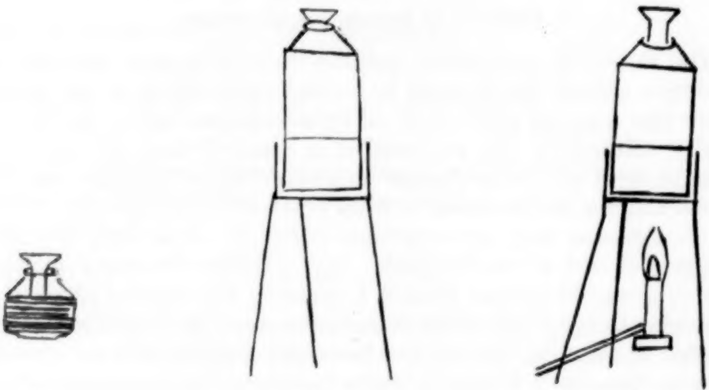
It has been estimated that at the peak of activities during 1957–58, more than one thousand scientists and technicians will be wandering the frozen Antarctic southland, working out from 33 separate stations. The United States have the honor of placing one of its outposts directly on the South Pole.

Rubber Paint adheres to metal, wood, plastic and concrete. Applicable by brush or spray, the paint dries in a continuous rubber film that is waterproof, as well as unaffected by acids, alkalis or fungus. It can be used to paint anything rom oil-treated shingles to steel boat hulls.

DEMONSTRATION TO SHOW THE OPERATION OF AN AUTOMOBILE THERMOSTAT

REBECCA E. ANDREWS
Woodrow Wilson High School, Washington, D. C.

It has been mentioned before in a previous "Easy Does It" that spare parts of an automobile may be found in a junk yard. There are always some pupils of high school age who, in scouting around, find these parts and who like to bring them to the school for classroom instruction. One of the parts that is easy to find and to bring to school is an automobile thermostat. See Figure 1.



1 2 3

Figures for Automobile Thermostat

With such a thermostat the physics teacher or, what is still better, the pupil who brought the thermostat to school can perform a demonstration to illustrate the operation of the automobile thermostat. It is a coincidence that with a little tapping or hammering the automobile thermostat just fits into the top of the conventional boiler that any physics teacher utilizes for the experiment on heat of vaporization. One would think that the two pieces—thermostat and boiler—were made for each other.

To operate the thermostat proceed as follows. Screw off the top of the boiler and pour some water into the boiler. Insert the bellows part of the thermostat into the opening in the top of the boiler and tap or hammer it so that it fits snugly. Mount the boiler on a stand and place a lighted Bunsen burner under the boiler. After a few minutes the air inside the thermostat bellows will be heated sufficiently so that its expansion causes the top of the thermostat to rise.

See Figures 2 and 3 for the appearance of the thermostat both before and after heating.

On the same day it is a good idea to have a diagram illustrating exactly how the top of the thermostat acts as a valve to control the flow of water from the engine to the radiator. If a very big diagram is made one year it can be stored and used again.

A CURIOUS PROBLEM IN PROBABILITY

R. F. Graesser
University of Arizona, Tucson, Arizona

The theory of probability includes many ingenious and curious problems among which might be classed the problem of the probability that a person aged x will die before a person aged y. In the following solution of this problem, it is assumed that the reader is familiar with the usual chapter on probability in a college algebra, which chapter should include a brief explanation of mortality tables, or life tables as they are sometimes called. We shall need only four columns of each of two life tables, viz.: a column headed x meaning age x; a second column headed l_x meaning the number of persons surviving to age x out of 100,000 persons born alive; a third column headed d_x meaning the number from this 100,000 persons who die between the ages x and $x+1$; and a fourth column headed L_x, where $L_x=(l_x+l_{x+1})/2$.

A person now aged x will be designated by (x). The probability that (x) will survive n years is then l_{x+n}/l_x, and the probability that (x) will die in the nth year from now is $(l_{x+n-1}-l_{x+n})/l_x$. For the solution of our proposed problem, we need first the probability that (x) will die in the nth year from now and (y) will be alive at the moment of the death of (x). This partial probability will then be summed from $n=1$ to the oldest age in the life tables for the solution of our problem. To obtain this first-needed probability, we make the assumption, common in actuarial mathematics, that the deaths in any one year are uniformly distributed throughout that year. Divide the nth year in t equal parts. Then the probability that (x) dies in the rth such part is d_{x+n-1}/tl_x. The probability that (y) survives to the end of this rth part is $l_{y+n-1+r/t}/l_y$ so that the probability that both these independent events happen is

$$\frac{d_{x+n-1}}{tl_x}\,\frac{l_{y+n-1+r/t}}{l_y}\,. \tag{1}$$

But, by our assumption of uniform distribution of deaths in a year, $l_{y+n-1+r/t}=l_{y+n-1}-rd_{y+n-1}/t$, using which we have for (1)

$$\frac{d_{x+n-1}}{tl_x}\left(\frac{l_{y+n-1}}{l_y}-\frac{r}{t}\,\frac{d_{y+n-1}}{l_y}\right). \tag{2}$$

The expression (2) is the partial probability for the happening of the event in question in the rth equal part of the nth year. The total probability for its happening in any one of the t parts of the nth year is the sum of (2) from $r=1$ to $r=t$, or

$$\frac{d_{x+n-1}}{l_x}\,\frac{l_{y+n-1}}{l_y}-\frac{d_{x+n-1}}{tl_x}\,\frac{d_{y+n-1}}{tl_y}\,\frac{t(t+1)}{2}.$$

Allowing t to become infinite, this becomes

$$\frac{d_{x+n-1}}{l_xl_y}\left(l_{y+n-1}-\frac{d_{y+n-1}}{2}\right).$$

Again using our assumption about the uniform distribution of deaths, the second factor of this product equals $(l_{y+n-1}+l_{y+n})/2$ or L_{y+n-1}. Hence we have

$$d_{x+n-1}L_{y+n-1}/l_xl_y, \tag{3}$$

which is the probability (x) dies before (y) in the nth year from the present. To obtain the total probability that (x) dies before (y) in any subsequent year, it is necessary to sum (3) from $n=1$ to the oldest age in the life tables.

Insurance companies use mortality tables based on insured lives. It is better for our purpose to use *United States Life Tables and Actuarial Tables* published by the Bureau of the Census. The latest issue of these, published in 1946, is for the years 1939–1941 and is obtainable for $1.25 from the U. S. Government Printing Office, Washington 25, D. C.

Suppose we want the probability that a man, who is white and aged 50, dies before his wife, who is white and aged 45. For the man we take l_x and the values of d_{x+n-1} from the life table for white males page 34. For the wife we take l_y and the values of L_{y+n-1} from the life table for white females, page 36. We calculate the product sum,

$$d_{50}L_{45}+d_{51}L_{46}+d_{52}L_{47}+\cdots+d_{108}L_{103},$$

which we divide by $l_x\cdot l_y=l_{50}\cdot l_{45}$. The result, 0.6761^+, is the probabilit that a man aged 50 dies before his wife aged 45. This calculation requires about an hour with a desk calculator. Younger ages will require more time, older ages less.

CLEVER QUESTION BEATS THE HEAT

JULIAN C. STANLEY
305 South Owen Drive, Madison, Wis.

In a certain country a prisoner stands in the execution chamber with the executioner. There are two chairs in the room, one lethally electrified and the other harmless. According to the law of the land, the man must choose a chair and sit in it. However, he is allowed to ask the executioner *one* question that may be answered simply "yes" or "no." Furthermore, the sentenced man knows that either the executioner *always* tells the truth or else he *always* lies, but he does not know which. What *one* question should he ask in order to determine *with certainty* which is the safe chair?

Sound tough? It is! But the prisoner need use just a little elementary logic in order to live. Those of you who have heard of communication theory may think that solving this problem requires more than one "bit" of information. Not so! A single question—the appropriate one—suffices.

Use all the ingenuity you can muster. Then check your answer against the solution on page 77. Good Luck!

THE QUANTITY OF VITAMINS DEPENDS UPON THE KIND

Evidence indicating that the quantity of vitamins required for normal nutrition depends to some extent on the kind of carbohydrates usually eaten was revealed to scientists attending the annual meeting of the American Chemical Society.

University of Wisconsin biochemists A. E. Harper and C. A. Elvehjem reported that less soluble—and therefore more slowly digested—forms of carbohydrates enable the body to get along an an lower vitamin intake than if the more soluble forms of carbohydrates are habitually consumed.

The less soluble forms of carbohydrates are the starches, the more soluble forms are the sugars.

"The decrease in vitamin requirements generally associated with the feeding of less soluble carbohydrates is considered to be the result of increased synthesis of vitamins by intestinal micro-organisms," Harper and Elvehjem reported.

They added that the intestinal contents of test animals fed less soluble carbohydrates contain vitamins in greater quantity than those fed the more soluble forms of carbohydrates. It is well known that many vitamins are synthesized by intestinal bacteria, and that this synthesis may be an important source of vitamins in animals and human beings on inadequate diets.

As a result of this increased vitamin supply, test animals fed the less soluble carbohydrates grew faster than those fed the more soluble ones, when vitamin supplies in diets were limited.

Scientists have known for some time that carbohydrates have what is termed a protein-sparing effect. This means that adequate carbohydrates in the diet will permit the proteins eaten to be turned into body machinery and repairs rather than burned for energy. As proteins are more expensive than carbohydrates, this permits the same efficiency from food for less expense.

Harper and Elvehjem have now found that utilization of low protein diet is improved when the carbohydrates in the diet are the less soluble forms—in other words, when starches rather than sugars are consumed.

THE STORY OF THE BAROMETER: AN EXAMPLE OF THE SCIENTIFIC METHOD

ROBERT H. LONG
Green Mountain Junior College, Poultney, Vt.

Of all the devices that come across the paths of science students, probably none is more common than Torricelli's barometer; and generally time is taken to get a glimpse of the history of this instrument that plays such an important role in laboratory measurements, and which, along with the more maneuverable aneroid barometer, is used to determine weather-predicting data and altitude.

However, the story of the barometer has another important use in the science classroom; this is its value as an original example of a *means by which a problem in science arises, a theory formulated, an experiment performed, and validation made.*

Keeping in mind the many variations of the so-called scientific method and the great opportunity for originality—including the use of the yet-unexplained "hunch," the story of this mechanically-simple instrument can do much toward revealing to younger students how the foundations of experimental science were built.

When the western world entered the seventeenth century, the learned minds of the times still leaned heavily on the ancient Aristotelian explanations of natural phenomena. For centuries these untested ideas were accepted at face value. Included among the many explanations was the suction phenomenon; Aristotle made it very simple: nature abhorred a vacuum; it was just as simple as that.

But as the seventeenth century dawned, the great Galileo (1564–1642) was breaching the strong buttress of Aristotelian philosophy; his classic experiment with falling bodies stands as a monument to this achievement. He called attention to the fact that water did not seem to rise more than 32 feet (a good measurement for those times) in a vacuum. He wondered *why nature seemed not to abhor a vacuum above this point.* But Galileo was getting old, so one of his disciples, Evangelista Torricelli (1608–1647), took up the problem.

Torricelli speculated as to whether mercury, being about fourteen times as heavy as water, would rise only one fourteenth as high in a vacuum. From this thinking there came a series of experiments that, besides resulting in the Torricellian barometer, unfolded an outstanding drama of the originality, the thoroughness and the validation needed to establish a scientific principle.

The well-known experiment followed, in which Torricelli inverted the mercury-filled tube in a trough containing the liquid and found his "guess" to be right—the mercury dropped until it stood at about thirty inches, with the "Torricellian" vacuum at the top.

He suspected the balancing force on the mercury to be caused by the pressure of the atmosphere, and that the slight day-to-day changes in the level of the liquid to be brought about by small variations in this air pressure. *Here a scientific hypothesis began to take form and replace an ancient philosophical explanation—nature abhors a vacuum.* Early death prevented Torricelli from going on with the hypothesis.

Blaise Pascal (1623–1662), French philosopher and mathematician, learned about Torricelli's experiment; *he repeated it with both mercury and water*, and became interested in the hypothesis to explain it. *He planned an experiment* (actually performed by his brother-in-law, Perier) *to confirm the explanation.*

A Torricellian barometer was set up at different stations (*using the same tube and mercury*) up to the summit of Puy-de-Dome, in the Auvergne region of France. The height of the mercury column showed a progressive lowering as the altitude increased. While these observations were being made, a second barometer, set up at the base of the mountain, recorded little change. It is interesting to observe at this point how the second barometer was used—*as a control*—to make sure the measured pressure at the base of the mountain remained about constant. The experiment seemed to confirm the hypothesis that the column of mercury was supported by air pressure, assuming, of course that air pressure would be less at higher altitudes. Robert Boyle added supporting evidence to this when, in 1659, he proved experimentally, by using a barometer in a bell-jar and an air pump, that the height of the fluid in a barometer depends on the external pressure.

Perier repeated the experiment at the foot and the summit of another mountain, nearby; *he obtained results similar to those of the first experiment.* And Pascal, personally, did the experiment many times on high buildings in Paris. In fact, the experiment became a favorite one of the times. So here in the history of the barometer we find an excellent example of an experiment being *validated by many trials, by different persons.*

Later the barometer and tables computed from Boyle's Law were used to estimate the height of the atmosphere and to establish a means of measuring altitude.

In the story of the mercury barometer we see an ancient explanation replaced by a scientific hypothesis; we see an experiment planned, with a control, to test the hypothesis; we see the experiment validated by many trials, along with a laboratory validation of the principle. And the story stands as an example of how historical perspective in science can add meaning and value to the science knowledge and instruments that we accept and use so readily today.

ANSWER TO "CLEVER QUESTION BEATS THE HEAT"

JULIAN C. STANLEY
305 S. Owen Drive, Madison, Wis.

The doomed man, pointing to a particular chair, says: "If I were to ask you, 'Is this the electrified chair?' would you say 'Yes'?"

Consider the four possible situations: (1) the indicated chair is electrified and the executioner is always truthful; (2) the chair is electrified and the executioner always lies; (3) the chair is harmless and the executioner truthful; (4) the chair is harmless and the executioner untruthful.

Take the first (electrified-truthful) possibility. Because the chair is electrified, if asked ***directly*** "Is this the electrified chair?" the truthful executioner would have answered "Yes," so, being consistently truthful, he says, "Yes (I would say 'Yes' if you asked me, 'Is this the electrified chair?')."

Now look at the second (electrified-untruthful) situation. If the executioner were asked directly, "Is this the electrified chair?" he, being a chronic liar, would say "No." But if asked the indirect question, in order to remain consistently untruthful he would have to deny that he would say "No" and claim that he would say "Yes." (The negation of a negation is an affirmation.)

Thus whether or not the executioner is truthful, a "yes" answer to the indirect question means that the chair is electrified. Does a "no" response surely mean that the chair is harmless? Let us see.

The third (harmless-truthful) possibility is straight-forward no-no, for if asked directly, the executioner would tell the truth by saying "No," and if asked indirectly he would say "No (I would not say 'Yes')."

In the fourth and last (harmless-untruthful) situation he would say "Yes" if asked directly, for the correct answer is "No," but if asked what he would say, in order to lie he must deny the "Yes" response by saying "No." Therefore, if the chair is harmless, the prisoner can be certain of a "no" response, regardless of whether or not the executioner is truthful.

(Note that even after determining which chair is safe, the man still has not learned anything concerning the executioner's truthfulness.)

The following table should help to make the above solution clearer. Some smart readers may have noted that the doomed man might have substituted "would you say 'No'?" in his question, but this beclouds the interpretation by making a "yes" answer mean that the chair is ***not*** electrified and a "no" response that it is.

	Truthful Executioner		Untruthful Executioner	
	Answer to direct question, "Is this the electrified chair?"	Answer to indirect question, "If . . . , would you say 'Yes'?"	Answer to direct question, "Is this the electrified chair?"	Answer to indirect question, "If . . . , would you say 'Yes'?"
Electrified Chair	Yes	**Yes**	No	**Yes**
Harmless Chair	No	**No**	Yes	**No**

Now Go Out and Confound Your Friends with This Brain Teaser!

1956 KALINGA PRIZE TO BE AWARDED AMERICAN AUTHOR AND PHYSICIST

Dr. George Gamow, Professor of Physics at the University of Colorado, Boulder, Colo., will receive the Kalinga Prize from Dr. Luther H. Evans, Director-General of the United Nations Educational, Scientific, and Cultural Organization in a brief ceremony at the United Nations Headquarters at 5.30 P.M. Friday, October 12.

The prize, awarded annually by UNESCO to a science writer selected by an international jury, was established in 1952 by Mr. B. Patnaik, of Cuttack, Orissa, India, for the dual purpose of recognizing outstanding interpretation of science to the general public, and of strengthening scientific and cultural links between India and other nations.

The winner receives a cash prize of 1,000 pounds sterling, and also is invited to the annual meeting of the Indian Science Congress and to spend a month visiting and lecturing in India. "Kalinga" was the name of an ancient empire of the Indian subcontinent—the modern state of Orissa lies within its boundaries—which was conquered in the Third Century B.C. by the Emperor Asoka, who was so appalled by the cost of his conquest in terms of human life and suffering that he swore never to wage war again.

Dr. Gamow is the fifth winner of the prize. He was selected from among eight writers nominated from as many countries. The jury this year was composed of Abdel Rahman, Professor of Astronomy at the University of Cairo, Egypt; L. J. F. Brimble, Director of Nature Magazine, Great Britain; and J. L. Jakubowski, Member of the Polish Academy of Sciences. Dr. Gamow was nominated by the Venezuelan Association for the Advancement of Science.

Previous winners of the prize have been Professor Louis de Broglie of Paris, Nobel Prize winner and Secretary of the Academie des Sciences (1952); Dr. Julian Huxley of London, Unesco's first Director-General (1953); Mr. Waldemar Kaempffert, science editor of the *New York Times* (1954); and Dr. August Pi Suner, Spanish physiologist and director of the Institute of Experimental Medicine at the University of Caracas, Venezuela (1955).

Head Maintenance Kit is designed for tape recorder owners. The kit contains a clearner and a lubricant, each in a two-ounce bottle, as well as special brush applicators and instrument manual.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2515, 2517, 2518, 2525. *C. W. Trigg, Los Angeles City College*

2527. *Proposed by Benjamin Greenberg, New York, N. Y.*

Solve:

$$x+1=y$$

$$x^y+y^x=17$$

Solution by Julian H. Braun, San Diego, California

By inspection one finds the only rational solution to be $x=2$, $y=3$. To complete the solution one should also find all the irrational solutions as well. If the value of y given by the first equation is substituted in the second equation we obtain

$$x^{x+1}+(x+1)^x=17. \tag{3}$$

If x is negative and of the form p/q and p is an even integer and q an odd integer then $x^{x+1}<0$, but if p is odd and q is odd then $x^{x+1}>0$. Hence, if x is irrational x^{x+1} may be regarded as double valued when x is negative. (It is also possible to infer complex values of x^{x+1} but we are presently investigating only the real roots.) In Eq. (3) call the left member z. Taking first $x^{x+1}<0$ we have on trying

$$x=-18/19 \quad \text{gives} \quad z=15.275;$$

$$x=-20/21 \quad \text{gives} \quad z=17.168.$$

However, we want z to be equal to 17. By successive approximation we ultimately obtain the solution $x=-0.95198^+$, $y=0.04802^+$. Similarly, we find that taking $x^{x+1}>0$ yields the solution

$$x=-0.94657^+, \qquad y=0.05343^+.$$

There are also infinitely many complex roots owing to the multivalued nature

of x^{x+1} when x is complex. However, obtaining these roots would be rather involved and will not be gone into here.

Solutions were also submitted by Charles H. Butler, Kalamazoo, Mich.; J. Byers King, Denton, Md.; J. W. Lindsey, Amarillo, Texas; C. W. Trigg, Los Angeles, Calif.; Alan Wayne, Baldwin, N. Y.; and the proposer.

2528. *Proposed by Brother T. Brendan, St. Mary's College, Calif.*

Check this statement: "If there are more trees than there are leaves on any one tree, then there exist at least two trees with the same number of leaves."

Solution by Charles H. Butler, Kalamazoo, Michigan

This must be considered under two cases.

Case 1, in which it is assumed that every tree has at least one leaf.

In this case the statement is true, because:

Let n = largest number of leaves on any tree.

Then there must be at least $(n+1)$ trees.

Then each tree must have either 1 or 2 or 3 or . . . or n leaves.

Consider the first n trees counted in order, and assume that no two of them have the same number of leaves, since this is mathematically possible, and under any other assumption there would be no problem. Then they will have respectively 1, 2, 3, . . . , $(n-1)$, and n leaves. But there is at least one more tree and it cannot have more than n leaves. Therefore it must have the same number of leaves as one of the first n trees, and there must be at least two trees with the same number of leaves.

Case 2, in which it is assumed that at least one tree is leafless.

In this case the statement we are considering is not necessarily true, as shown in the following argument.

Since n is finite, though possibly very large, let us take n = a small positive integer, say 5.

Now each tree must have either 0 or 1 or 2 or 3 or 4 or 5 leaves. But there are at least 6 trees (that is, $(n+1)$ trees) and these might have respectively 0, 1, 2, 3, 4, and 5 leaves. That is, in such a case no two trees would have the same number of leaves although there would be more trees than leaves on any one tree. The extreme case would be if there are only two trees, one of which has just one leaf and the other has no leaves.

Solutions were also offered by Julius Sumner Millier, El Camino, Calif.; C. W. Trigg, Los Angeles, Calif.; Alan Wayne, Baldwin, N.Y.; and the proposer.

2529. *Proposed by J. W. Lindsey, Amarillo, Texas*

Find the volume of the largest sphere that can be cut from a cone of revolution 14 inches high and 12 inches in diameter.

Solution by Brother Felix John, Philadelphia, Pa.

The largest sphere that can be cut from the cone of revolution is the sphere inscribed in it.

In the figure, right triangles PNR and PMO are similar because they have a common acute angle. Then,

$$r/6 \text{ equals } (14-r)/2(58)^{1/2}.$$

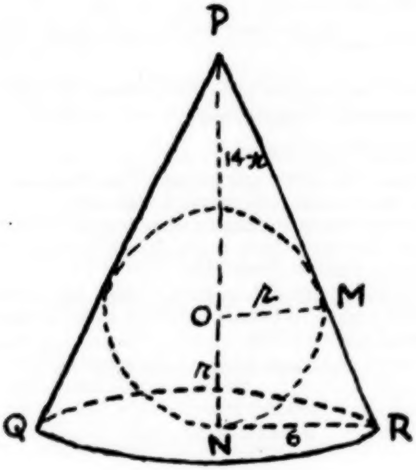
Whence,

$$r \text{ equals } 42/(\sqrt{58}+3)$$

Since V equals $4/3\ \pi\ r^3$, the volume equals 259.14 cu. in. (approximately).

Solutions were also submitted by Luella Boehnlein, Edmonton, Canada;

Julian H. Braun, San Diego, Calif.; Charles H. Butler, Kalamazoo, Mich.; J. Byers King, Denton, Md.; Alan Wayne, Baldwin, N.Y.; and the proposer.



2530. *Proposed by Julius Sumner Miller, El Camino College, California*

A man of mass M stands on a platform of mass m. He pulls on a rope which is fastened to the platform and which runs over a pulley on the ceiling. With what force must he pull to give himself and the platform an upward acceleration a?

Solution by the Proposer

Let T be the tension in the rope and F the force with which the platform pushes upward on the man. Isolating the man and invoking Newton's Second Law we may write

$$T-Mg+F=Ma.$$

Similarly for the platform

$$T-mg-F=ma.$$

Whence

$$T=1/2(M+m)(a+g).$$

It is interesting to examine limiting cases. If

$$a=0,\ T=1/2(M+m)g,$$

which is intuitively clear. And

$$F=1/2(M-m)g,$$

which is interesting.

2531. *Proposed by Brother Felix John, Philadelphia, Pa.*

Show that

$$3^{2n+5}+160n^2-56n-243$$

is divisible by 512.

Solution by C. W. Trigg, Los Angeles City College

When $n=0$, the expression vanishes. For $n>0$, it may be written

$$3(2^3+1)^{n+2}+160n^2-56n-243$$

$$=3\left[1+(n+2)2^3+\frac{(n+2)(n+1)}{2!}(2^3)^2+(2^3)^3F(n)\right]+160n^2-56n-243$$

$$=3(2^9)F(n)+3+24n+48+96n^2+288n+192+160n^2-56n-243$$

$$=3(512)F(n)+256n^2+256n$$

$$=3(512)F(n)+256n(n+1).$$

Now $n(n+1)$ is even for all integer values of n. Therefore the expression is divisible by 512 for all non-negative integer values of n.

NOTE TO THE EDITOR: This is the same problem as 2510 for which I submitted a proof by induction. Probably both methods will interest your readers. This might be considered as a Method II for 2510.

The proof published on page 575 of the October 1956 issue erroneously assumes that if $F(n+1)-9f(n)=512k$ then $F(n)$ is divisible by 512. That this is not true may be seen by considering

$$\phi(n)=3^{2n}+160n^2-56n-243.$$

Now

$$\phi(n+1)-9\phi(n)=512k,$$

but

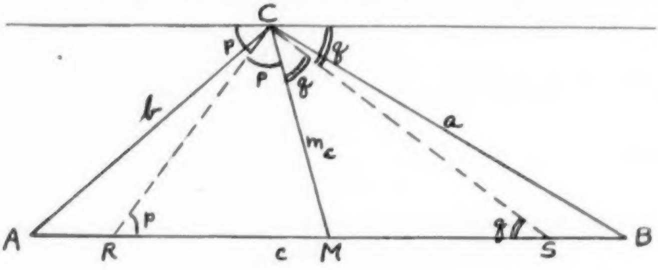
$$\phi(1)=-130.$$

A solution was also offered by the proposer.

2532. *Proposed by Nathan Altshiller-Court, University of Oklahoma*

Find the length (in terms of the sides) of the segment determined on a side of a triangle by the bisectors of the angles formed by the median relative to that side and the parallel to that side through the opposite vertex.

Solution by Charles H. Butler, Kalamazoo, Michigan



Using the notation on the accompanying figure it is seen at once that

$$\angle CRS=\angle p \quad\text{and}\quad \angle CSR=\angle q,$$

and that

$$\angle p+\angle q=90°.$$

Therefore

$$RM=MS=m_c \quad\text{and so}\quad RS=RM+MS=2m_c.$$

Now the length of the median m_c of a triangle ABC is given by the formula

$$m_c = \sqrt{2a^2+2b^2-c^2}.$$

This formula can be found in certain textbooks on plane geometry (cf. McCormack (Appleton, 1928), p. 342) or it can be easily established by using projections or the law of cosines. Since the required segment $RS = 2m_c$, it follows that

$$RS = \sqrt{2a^2+2b^2-c^2}$$

which expresses the length of the required segment in terms of the sides of the triangle.

NOTE: The diagram used here illustrates the case where $\angle ABC > 90°$. The generality of the formula is not impaired if $\angle ABC < 90°$, but in that case R and S will lie on extensions of the base instead of lying between A and B.

A solution was also offered by Ada Scarlett, Melbourne, Australia.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2529. *Doris Burke, Georgian Court College, Lakewood, N.J.*

PROBLEMS FOR SOLUTIONS

2551. *Proposed by Hale Pickett, Redondo Beach, Calif.*

What is the radius of a circle, which is tangent to an edge of a one inch cube, tangent to an adjacent diagonal of a face, and tangent to the circle formed by the diagonal plane of a one inch cube, cutting an inscribed sphere whose radius is 0.5 of an inch?

2552. *Proposed by Dwight L. Foster, Florida A. & M. College.*

Forces act at the middle points of the sides of a triangle at right angles to the sides and respectively proportional to them. Show that if they act inwards or outwards, they are in equilibrium.

2553. *Proposed by Vincent C. Harris, San Diego, Calif.*

Given α and β functions of x.

$$(1) \qquad \lim_{x\to a} (\alpha-\beta)=0$$

$$(2) \qquad \lim_{x\to a} \frac{\alpha}{\beta}=1.$$

Which of the above statements gives more information, if either?

2554. *Proposed by Brother Felix John, Philadelphia, Pa.*

In an equilateral triangle, the circumradius, R, is twice the inradius, r. Is the converse true? That is, if the circumradius of a triangle equals twice the inradius, is the triangle necessarily equilateral?

2555. *Proposed by N. Kactasamaiyer, Madras, India.*

ABC is a triangle; D and E are two points on AC and AB respectively such that $BD = CE$ and BD and CE intersect each other on the bisector of the vertical angle A. Show that $AB = AC$.

2556. *Proposed by Hugo Brandt, Chicago, Ill.*

The first six members of a series are $a_1=2$, $a_2=3$, $a_3=4$, $a_4=11$, $a_5=29$, $a_6=62$. Find an expression for the general member $a_n=f(n)$; find the maximum a_n; find the first negative a_n.

BOOKS AND PAMPHLETS RECEIVED

FUNDAMENTAL CONCEPTS OF HIGHER ALGEBRA, by A. Adrian Albert, *Professor of Mathematics, The University of Chicago.* Cloth. Pages ix+165. 15×23 cm. 1956. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $6.50

DISCOVERY OF THE ELEMENTS, Sixth Edition, by Mary Elvira Weeks. Cloth. Pages x+910. 15×23.5 cm. 1956. Mack Printing Company, Easton, Pa.

AN INTRODUCTORY COURSE IN COLLEGE PHYSICS, Fourth Edition by Newton Henry Black, *Assistant Professor Emeritus of Physics, Harvard University,* and Albert Payson Little, *Professor of Physics and Mathematics, Wayne University.* Cloth. Pages viii+786. 14×21. cm. 1956. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $6.75

FUN WITH FIGURES, by J. A. H. Hunter. Cloth. Pages xi+160. 12×19 cm. 1956. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $3.00.

MATHEMATICS OF BUSINESS, ACCOUNTING, AND FINANCE, by Kenneth Lewis Trefftzs, Ph.D., *Professor of Finance and Head of the Department of Finance, University of Southern California,* and E. Justin Hills, Ph.D., *Department of Mathematics, Los Angeles City College.* Cloth. Pages xii+591. 15×23.5 cm. 1956. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $4.50

DICTIONARY OF POISONS, by Ibert Mellan and Eleanor Mellan. Cloth. 150 pages. 13.5 21 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

SPECTROSCOPY AT RADIO AND MICROWAVE FREQUENCIES, by D. J. E. Ingram, M. A. (Oxon), D. Phil. (Oxon). *Lecturer and Research Fellow, University of Southampton.* Cloth. Pages xii + 332. 13×21.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $15.00.

CHEMISTRY MAGIC, by Kenneth M. Swezey. Cloth. Pages x+180. 15×23 cm. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $4.50.

EDUCATION IN THE U.S.A., by W. Kenneth Richmond, M. A., M. Ed. *Lecturer in Education, University of Glasgow.* Cloth. 227 pages. 12×18.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.50

ATOMIC ENERGY, by A. Radcliffe, B.Sc., A.I.P., and E. C. Roberson, B.Sc., Ph.D., A.R.I.C. Cloth. 142 pages. 12×18.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

PHYSICS FOR EVERYBODY, by Germaine and Arthur Beiser. Cloth. 191 pages. 13.5×20.5 cm. 1956. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York 10, N. Y. Price $3.50.

A LABORATORY MANUAL FOR EARTH SCIENCE SURVEY: ASTRONOMY, GEOLOGY AND METEOROLOGY, by Victor L. Crowell, *Professor of Science and Head of the Department,* and Alan Lutz, *Assistant Professor of Science, State Teachers College, Trenton, N. J.* Paper. Pages vi+102 plus Charts. 21×27 cm. 1956. Burgess

Publishing Company, 426 South Sixth Street, Minneapolis 15, Minn. Price $3.00.

LECTURES ON THE ICOSAHEDRON AND THE SOLUTION OF EQUATIONS OF THE FIFTH DEGREE, by Felix Klein. Second and Revised Edition. Paper. Pages xvi+289. 13×20.5 cm. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.85.

HOW TO IMPROVE YOUR MIND, by Baruch Spinoza. Paper. 90 pages. 10.5×18.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price 95 cents.

CALCULUS QUICKLY, by William R. Ransom, *Emeritus Professor of Mathematics, Tufts College*. Paper. Pages viii+60. 14×21.5 cm. 1956. William R. Ransom, 13 Barrows Road, Reading, Mass.

THE ROLE OF MEANING IN TEACHING THE FUNDAMENTAL PROCESSES, by Herbert H. Hannon and Pearl L. Ford, *Department of Mathematics, Western Michigan College, Kalamazoo, Michigan*. Paper. 20 pages. 15×23 cm. 1956. School of Graduate Studies, Western Michigan College, Kalamazoo, Mich. Price 25 cents per copy.

ARITHMETIC COMPUTATION TEST AND MANUAL, by Richard Madden, *San Diego State College*, and Philip Peak, *Indiana University*. Paper. 18 pages. 21.5 ×28 cm. 1956. World Book Company, Yonkers-on-Hudson, New York.

BOOK REVIEWS

WORLD AIRCRAFT RECOGNITION MANUAL, by C. H. Gibbs-Smith and L. E. Bradford. Cloth. Pages xv+269. 14×20 cm. 1956. John DeGraff, New York, N.Y. Price $3.50.

This book would be a valuable addition to any library as a reference book. The book approaches the problem of aircraft recognition and identification by grouping the planes according to the shape of the wings.

The sections describe planes which are: (I) delta winged, (II) swept winged, (III) straight winged, and (IV) rotary winged (helicopters). There is also a short section on techniques to be developed in plane recognition. In each section, the more common planes of each type are fully described and shown in actual photographs as well as four views of the silhouettes of the plane. In all cases the following information is given: name, manufacturer, type or use, how powered, size, and a brief description. In all, 13 delta winged, 45 swept winged, 159 straight winged, and 27 rotary winged planes are shown in black and white photographs. The index lists the common name or number of each plane for easy access to finding any plane. As stated at the beginning, this book should be in every school library enrolling more than two students interested in airplanes.

E. WAYNE GROSS
University School
Bloomington, Indiana

REFLECTIONS OF A PHYSICIST, Second Edition, by Percy Williams Bridgman, Pages xiv+576. 14.5×22.0 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

This is a collection of talks and papers in which the author amplifies and applies his concept of *operationalism* as *the* method of science. Ten more papers, about 28% more pages, are included in this reissue.

A sampling, from its thirty-two chapters, indicates the range of his "Reflections." Under five general groupings: General Point of View; Applications to Science Situations; Primarily Social; Specific Situations and lastly, Prophetic,

are found titles with headings: Science, Public and Private; On Scientific Method; Science and Common Sense; The New Vision of Science; Recent Change (Regarding) Cause and Effect; The Time Scale; Struggle for Intellectual Integrity; Scientist and Social Responsibility; Strategy of the Social Sciences; Science, Materialism and the Human Spirit; A Challenge to the Physicists and New Vistas for Intelligence.

A footnote for each chapter indicates: the occasion, the time and the medium of the paper's first publication. The chronological spread is from 1929 through 1954. The order in the book is not chronological nor is there much evidence of logical sequence other than the five groupings mentioned above. There is an index of authors; none for subject-matter. Those most quoted are Einstein, Heisenberg and Newton.

This is essentially a book for browsing. It hardly needs to be said that some acquaintance with the author's original 1926 presentation of operationalism, under the title, "The Logic of Modern Physics," would greatly enhance a reader's understanding and appreciation of this.

In his preface, to the first edition, the author says, "(In becoming) operationally self-conscious I (came to) a new way of handling my mind—my thinking (took) a different 'feel' from that before. Perhaps this collection will serve the purpose of enabling the reader, as he could not from the isolated papers as they appeared over a span of years, to get a little of that 'feel' for himself, and to attempt to apply it to his own questionings." And may it be added, the whole series are proper stimuli toward "Intellectual Integrity?"

B. CLIFFORD HENDRICKS,
Longview, Washington

ANALYTIC GEOMETRY, ***Fifth Edition***, by Clyde E. Love and Earl D. Rainville, ***The University of Michigan***. Cloth. Pages xiv+302. 13×20 cm. 1955. The MacMillan Company, New York City, N.Y. Price $4.00.

This fifth edition of analytic geometry needs little introduction to mathematic instructors, as most of us are familiar with one or more of the earlier editions. It is a text on analytic geometry, rather than a text combined with calculus or with algebra and trigonometry. It contains the topics usually found in a text on analytic geometry and has a large number of exercises. The definition and theoretical discussions are clearly written and should be readily understood by students.

After an introductory chapter on rectangular coordinates, polar coordinates are introduced. The distance formula is developed, and a discussion of the choice of coordinate systems presented. The formulas for the relationship of polar and rectangular coordinates are developed in the chapter on lines. Thus polar coordinates are used throughout the book in the study of lines, circles, and conics, and not treated as an isolated topic. Curve tracing in polar coordinates is discussed in a chapter on algebraic curves.

Many lists of exercises in this text give application to problems, which indicate some of the uses of analytic geometry. The Circles of Appolonius are discussed. Translation of axes is introduced in the first chapter on conics, and used in the study of each curve. Rotation of axes and a study of the general second degree equation are given in a separate chapter. There are chapters on tangents and normals, curve fitting, and solid analytic geometry.

The exercises are adequate in number and well graded. The theory is illustrated by drawings, which are arranged to make attractive pages. This text should be examined by instructors who teach analytic geometry.

HILL WARREN
Lyons Township Junior College
LaGrange, Illinois

MODERN TRIGONOMETRY, by John C. Brixey and Richard V. Andree, *The University of Oklahoma*. Cloth. Pages xii+203. 16×24 cm. 1955. Henry Holt and Company, New York, N.Y. Price $3.25.

This text emphasizes the analytic portions of trigonometry rather than the solution of triangles. It gives the foundation needed for more advanced courses and gives information about the nature of these courses. The authors state that "The choice of text and problem material in this book was influenced by interviews and correspondence with many engineers, physicists, social scientists, and mathematicians. The introductory chapter is a review of Algebra including fractions, functional notations, solution of equations and coordinate systems." This inductory chapter is followed by chapters on the general angle, logarithums and exponents, and the solution of triangles. In these chapters, theory rather than computational skill is stressed. Very little space is given to the solution of right triangles. Drill problems on the law of sines and cosines are provided. Chapters on graphs, equations, and identities follow. Chapter VII is on polar coordinates. This chapter includes the relationship of polar and rectangular coordinates, and a study of loci in polar coordinates. Students are taught to graph, and to derive equations in polar coordinates. The next chapter is on the complex plane and complex numbers. A final chapter deals with topics from more advanced mathematics. Some of the topics treated are matrix multiplication, angle trisection, topology, and quaternings. The text includes many excellent drawings, a generous supply of worked exercises, self tests at the end of the chapter, and four place tables. Answers are given to many of the exercises. The answers include many graphs, charts, and teaching suggestions.

Students with average ability and minimum high school training might find this text difficult. Students with some experience with the trigonometric functions, and a good background in algebra, especially those in the upper one-third of their high school class, should find the text interesting and valuable. Trigonometry is not presented as an isolated course, but its relationship to other mathematic courses is shown. A good text for students who will take advanced mathematics, as well as those who wish to have some knowledge of the nature of mathematics.

HILL WARREN

SOURCEBOOK OF LABORATORY AND FIELD STUDIES FOR SECONDARY SCHOOL BIOLOGY COURSES

High school teachers of biology who are especially interested in improving laboratory and field work in secondary school biology courses are invited to apply for appointment to a group that will prepare a sourcebook of laboratory and field studies for such courses. The project is sponsored by the Committee on Educational Policies of the Biology Council, Division of Biology and Agriculture, National Academy of Sciences-National Research Council, and by Michigan State University, with the support of grants from the National Science Foundation. The sourcebook will be developed at an eight-week writing conference, to be held June 24 to August 16, 1957, at Michigan State University, East Lansing, Michigan.

It is generally agreed that stimulating instruction in laboratory and field is a vital part of a rewarding high school biology experience. Giving students opportunities to conduct observations and experiments on plants and animals arouses interest, deepens their understanding of living systems, and provides experience with scientific methods of inquiry. Unfortunately, despite its importance, laboratory and field study is too often pedestrian and unimaginative. One way to improve the situation is to supply teachers with a collection of superior exercises, realistically adapted to high school situations. All teachers could then use procedures developed by particularly capable teachers. This is the purpose of the sourcebook, which will contain a series of complete exercises from which individual teachers can draw ideas, studies for particular topics, or the laboratory and field work for entire courses.

The material will be developed by a group of 20 high school teachers and 10 college and university biologists. The prime requirement for participants is a

creative, imaginative approach to laboratory and field studies. All interested high school biology teachers are invited to apply. Biologists and school administrators are also urged to submit the names of teachers who are well qualified for the assignment. Each applicant or nominee will be sent a form asking for information on his background and experience, and evidence of his ability to contribute to the preparation of the sourcebook. The final selection will be made on the basis of two essays submitted by each applicant who passes a preliminary screening. One essay will illustrate how a topic supplied by the Committee can be converted into a study for high school use; the other will present an exercise the teacher has devised. The purpose of the essays is to give the Committee on Educational Policies a basis for judging applicants' ability to conceive and write stimulating laboratory or field studies.

The essays will also form a part of the pool of ideas for the sourcebook. Manuscripts so used will be credited to their authors, who may thus appear in the publication even if they are not selected to participate in the conference. The writing team will also have access to other collections of exercises, including those gathered by the Committee in preparing a series of sourcebooks of laboratory and field studies for college courses in the biological sciences.

The Committee has already selected the college and university participants. This is a group of successful teachers of introductory courses. Highly skilled in developing laboratory and field instruction, they are experts in different major areas of biology, share a sympathetic understanding of secondary-school problems, and possess personal qualities that make them helpful and creative contributors in a group enterprise.

Each participant will receive a stipend of $1,000. His round trip travel expenses between his home and East Lansing will also be paid. From the stipend he will be expected to pay his own living expenses during the conference. The University will provide housing and dining facilities at reasonable prices for teachers and their families. For leisure hours the campus and the surrounding community and countryside offer a wide variety of recreational and cultural resources.

In preparation for the conference the Committee has asked a panel of outstanding high school biology teachers to develop topical outlines for modern secondary-school biology courses. The outlines will supply a framework for the sourcebook, but should also be directly useful to teachers. Members of the panel are Arthur J. Baker, Community High School, Crystal Lake, Illinois, Chairman; William Jones, Handley High School, Winchester, Virginia; Paul Klinge, Howe High School, Indianapolis, Indiana; Joseph P. McMenamin, Oak Park and River Forest High School, Oak Park, Illinois; Brother G. Nicholas, La Salle High School, Cumberland, Maryland; Miss Florence Gardner, West Orange High School, New Jersey.

The Conference will be directed by Dr. C. A. Lawson, Head of the Department of Natural Sciences in the Basic College at Michigan State, and a member of the Committee's Subcommittee on Publications. Participants will have access to ample laboratory and library facilities. Exercises developed by the Conference will be tested in a variety of high schools during 1957–8, revised as necessary, and published by the fall of 1958, under the auspices of the Academy-Research Council.

Completed applications should be submitted by January 31, 1957. All correspondence concerning the project should be addresssed to:

Committee on Educational Policies
Division of Biology and Agriculture
National Research Council
2101 Constitution Avenue, N.W.
Washington 25, D. C.

Collapsible Tanks for storing liquids are made of rubberized nylon. One of the 15,000-gallon tanks folds into a package eight feet long by two and one-half feet in diameter when empty. They expand to 45 feet by 11 feet by six feet when filled.